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CORRELATION OF GASTROSCOPIC, ROENTGENOLOGIC AND PATHOLOGIC FINDINGS IN DISEASES OF THE STOMACH

AN ANALYSIS OF 245 PROVED CASES*

PANCOAST LECTURE†

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I AM very much honored by the invitation to address this learned society, and I wish now to express my thanks to you and your committee for selecting me to do so. To be included in a list of lecturers with Dr. George W. Holmes of Boston, Dr. Lawrence Reynolds of Detroit and Dr. D. B. Phemister of Chicago is indeed a privilege, and to give a Memorial Lecture in honor of Dr. Henry K. Pancoast, undoubtedly the leading radiologist of his time, marks an important occasion in my medical career.

According to Dr. Pendergrass[7] the first department of roentgenology in the United States was established by the University of Pennsylvania in 1896, and in 1902 Dr. Pancoast was appointed skiagrapher in charge of this department. Ten years later, he was made Professor of Roentgenology and was elected President of the American Roentgen Ray Society. In 1933 he was elected to the presidential chair of the first American Congress of Radiology, a spontaneous recognition of his long and fruitful life of service to radiology.

I have been asked this evening to discuss the correlation of gastroscopic, roentgenologic and pathologic findings in diseases of the stomach. The word "correlation" is well chosen for it implies cooperation between the three departments and cooperation is the keynote to successful progress. The roentgenologist always has the first chance to examine the patient. If the findings are fairly obvious, he will probably not suggest gastroscopy. The clinician, however, may wish confirmation by gastroscopy. If the roentgen findings are doubtful gastroscopy is always indicated. The pathologist comes into the picture routinely on resected or autopsy specimens. As an indication of the excellent relationship between the roentgenologist and the endoscopist at the Massachusetts General Hospital, I would like to point out that more requests for gastroscopy come from the Department of Roentgenology than from any other source. In other words, gastroscopy is an additional method of examining the stomach, supplementary and complementary to roentgenology, but not in any sense a rival method.

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† Pancoast Memorial Lecture delivered before the Philadelphia Roentgen Ray Society, November 2, 1944.

There is a saying that "comparisons are odious." In the present discourse, however, it will be of interest to draw certain comparisons as to the relative advantages and disadvantages of each method of study under various circumstances. Roentgen examination should always be performed first not only because it is easier and safer but also because it gives indispensable evidence regarding the esophagus. Before blindly passing the flexible gastroscope, the endoscopist must be assured of an essentially normal esophageal lumen. Both methods are so comparatively easy, safe and well established that it seems unnecessary to go into any detail regarding technique, indications, or contraindications. The important question before us is that of correlating the results of our studies in gastroscopy, roentgenology and pathology.

For this purpose, out of a total of 1,691 gastroscopies, I have carefully selected 245 cases for study. These are chosen because in each case there has been roentgen examination, gastroscopy, and pathological report. It is noteworthy that in a difficult case the roentgenologist may examine the patient on several occasions, whereas the gastroscopist usually has only one opportunity to make his examination. This is due in part to the relatively more difficult gastroscopic technique and in part to the fact that the gastroscopic method is newer and less well established. The 245 cases studied include carcinoma (125), gastric ulcer (50), duodenal ulcer (25), jejunal ulcer (8), gastritis, (16), benign tumor (7), lymphoma (5), sarcoma (2), metastatic carcinoma (3), normal stomach (4).

CARCINOMA

One hundred and twenty-five cases of proved carcinoma have been included for the purpose of this report. The two methods were equally good 67 times, the roentgenologist demonstrating a fairly obvious tumor mass and the gastroscopist confirming the diagnosis. In 3 cases the methods were equally doubtful, question of ulcer or malignancy in 2 of them, and question of neoplasm in 1 case. In 3 cases both were wrong —(1) a proved cancer treated as severe hypertrophic gastritis for two years (a serious mistake, the responsibility for which lies on the writer as gastroscopist and also on the roentgenologist of an outside hospital); (2) a proved cancer missed completely by both methods, and (3) a proved cancer thought to be a benign ulcer. In the remaining 52 cases a more accurate or more valuable report was given by the roentgenologist 32 times, by the gastroscopist 20 times.

An evaluation of these 52 cases is necessarily difficult and perhaps somewhat arbitrary but I believe it will serve to bring out the relative merits of each method. In 25 of the 32 cases where the roentgen ray was more valuable, gastroscopy failed to demonstrate the lesion at all. The reasons for gastroscopic failure in these 25 cases were as follows: (*a*) obstruction at cardia (7 cases), all due to tumor mass at the cardiac orifice; (*b*) blind area of the lesser curvature of the antrum (4 cases); (*c*) prepyloric area not seen (4 cases); (*d*) lesion in the pylorus not visible (4 cases); (*e*) spasm of antrum (2 cases); (*f*) blind area of fundus (2 cases); (*g*) excessive secretion (2 cases). In other words, some of the mechanical difficulties of gastroscopy are still unsolved. The retrograde objective lens, omniangle mirror, mechanism for proximal control of the tip of the gastroscope, and biopsy forceps have been helpful, but they are limited modifications which have not by any means solved all the problems. For lesions obstructing the cardiac orifice I use the open tube gastroscope with biopsy when possible. Such tumors quite commonly invade the lower end of the esophagus, in which case esophagoscopy may give a positive diagnosis. Even when the lower esophagus appears grossly normal a biopsy may show submucosal extension of the tumor. The transthoracic approach is indicated for tumors in these areas. Owing to the peculiar shape of the stomach, lesions of the lesser curvature of the antrum, prepyloric area and pylorus are more difficult to see than

lesions in the corpus, not only because they are farther from the objective lens but also because they may be hidden around the corner behind the angulus. Certain parts of the fundus may be impossible to see, especially high up toward the lesser curvature. Finally, excessive secretion will obviously interfere with a proper examination.

The other 7 cases where the roentgen examination was more valuable than gastroscopy may be analyzed as follows:

Case 1. I. F. M. (M.G.H., U No. 95735). On the first roentgen examination the examiner reported an active penetrating ulcer 1.5 cm. long, 0.5 cm. deep on the lesser curvature at the junction of the middle and lower thirds. Three weeks later another roentgenologist reported shortening of the lesser curvature with a 3 cm. crater just distal to the angle of the stomach. Histopathological malignancy could not be ruled out by the roentgenologist who suggested gastroscopic examination. The gastroscopist reported very sluggish peristalsis passing over the antrum and through the pylorus. Several shallow ulcerations were seen on the angulus with reddening, edema and verrucous elevations. The gastroscopic diagnosis was multiple gastric ulcers with superficial and hypertrophic gastritis. Exploratory laparotomy revealed a very extensive inoperable carcinoma involving almost all of the lesser curvature of the stomach. A biopsy taken from the omentum was reported metastatic carcinoma.

Comment. The roentgen examination was definitely superior to gastroscopy in this case. The gastroscopist apparently did not see the large 3 cm. crater beyond the angulus and thought the verrucous appearance of the lesser curvature was due to gastritis. Greater experience and improvements in the instrument in the seven years since this patient was examined might lead to more accurate gastroscopic diagnosis today.

Case 2. G.R. (M.G.H., U No. 411134). The roentgenologist reported a thickened, elongated rigid pylorus without peristalsis—question of carcinoma. The gastroscopist thought he saw normal peristalsis passing down to a normal pylorus, with a diffuse verrucous eroded mucosa in the body of the stomach and made a diagnosis of severe hypertrophic gastritis or lymphoma. At operation a small carcinoma was found about 2 inches from the pylorus. The rest of the stomach showed a marked gastritis.

Comment. The roentgenologist was correct; the gastroscopist may have seen only a prepyloric contraction which he mistook for the normal pylorus.

Case 3. L. R. (M.G.H., U No. 56379). In this case nine roentgen examinations were made over a period of thirteen months. The report was active gastric ulcer, old duodenal ulcer and hypertrophic gastritis; six months later the crater was markedly decreased in size; a year later "no active ulcer"; thirteen months later old duodenal ulcer and gastritis, suggestion of a shallow ulcerated carcinoma along the posterior wall near the lesser curvature. During this period three gastroscopies were performed, with the following findings: (1) active gastric ulcer with hypertrophic gastritis; (2) no ulcer can be seen, no evidence of malignancy; (3) unsatisfactory due to bleeding.

Comment. After nine examinations the roentgenologist raised the question of malignancy. Gastroscopy at that time was unsatisfactory but the gastroscopist advised surgery because of the persistence of symptoms and inability to work.

Case 4. A.C. (M.G.H., U No. 343070). In this case the roentgenologist first reported a benign appearing ulcer at the junction of the middle and lower thirds. Three weeks later the large ulcer crater was unchanged in size, there was absent peristalsis, 100 per cent retention, and malignancy was a distinct possibility. The gastroscopist thought the lesion was benign because it had sharp margins and a clean base. At operation, the surgeon believed he was dealing with a benign lesion and the pathologist thought the lesion was benign from the gross appearance. Microscopically "in the mucosa carcinoma is found only in a small zone immediately around the ulcer."

Comment. In this case Schindler's[9] claim that the presence of the circulating blood enables the gastroscopist to distinguish benign from malignant ulcer was not borne out.

Case 5. J.G.D. (M.G.H., U No. 338191) The

Fig. 1. Case 7. Roentgen appearance showing one or more ulcerations of the antrum in an area of thickened gastric wall. The roentgenologist was correct in believing this to be probably malignant. The gastroscopist thought the ulcer was probably benign.

roentgen examination demonstrated an organic obstruction in the lower end of the stomach with 100 per cent retention at the end of six hours. The lesion could not be definitely visualized but the findings were consistent with obstructing ulcer or carcinoma. At gastroscopy no peristalsis was seen. Instead of the pylorus there was seen a circular opening, possibly representing a stenosed pylorus, with one erosion and some proliferation but probably not malignant—more consistent with an obstructing ulcer and marked gastritis than with carcinoma.

Comment. This is probably an error in gastroscopic interpretation due to lack of experience, as the examination was made in 1934. It is to be noted also that the roentgenologist failed to see the lesion. This case might well be classified as both methods equally doubtful, but the gastroscopist was in error as he definitely favored a benign lesion.

Case 6. B.O. (M.G.H., U No. 240438). The roentgen report described a large ulcerated lesion on the posterior wall near the lesser curvature grossly benign (incomplete examination). The gastroscopist failed to see the large ulcer, but reported the angulus 1.5 to 2.0 cm. in diameter remaining in a fixed position. There were multiple areas of ecchymosis, increased reddening, superficial ulceration, edema, and irregular verrucous markings. The verrucous elevations varied in size from 1 to 2 mm. but did not appear sufficiently nodular for a diagnosis of carcinoma to be made.

Comment. The roentgenologist certainly described the important lesion in this case, though he failed to call it malignant. The gastroscopist should probably have thought more seriously about the fixed position of the angulus as an indication of carcinoma.

Case 7. S.Y. (M.G.H., U No. 334489). The roentgenologist demonstrated one or more ulcerations of the antrum in an area of thickened gastric wall which he thought was probably malignant, possibly lymphoma (Fig. 1). The gastroscopist found multiple gastric ulcers with distortion of the peristaltic wave at one examination but no distortion at a second gastroscopy. He felt it was "probably benign but strongly advised gastric resection." The pathological report was adenocarcinoma in situ with three shallow secondary peptic ulcerations.

Comment. The roentgen examination here had the advantage in demonstrating a thickened gastric wall and an ulcer in the prepyloric area.

In this series of proved carcinomas gastroscopy appeared to be more valuable than the roentgen ray in 20 cases grouped as follows:

Group A. Roentgen examination: gastric ulcer? carcinoma; gastroscopy: carcinoma (7 cases)
Group B. Roentgen examination: benign gastric ulcer; gastroscopy: gastric ulcer ? carcinoma (5 cases)
Group C. Roentgen examination: doubtful; gastroscopy: carcinoma (5 cases)
Group D. Roentgen examination: polyp; gastroscopy: carcinoma (1 case)
Group E. Roentgen examination: gastric ulcer; gastroscopy: malginant polyps (1 case)
Group F. Roentgen examination: gastritis; gastroscopy: carcinoma (1 case)

As an example of *Group A*, I will cite the following:

Case 8. M.G. (M.G.H., U No. 303682). At roentgen examination the antrum of the stomach showed a large ulceration measuring approximately 3 cm. in length. There was a very marked induration around the ulceration. The condition was considered as probably malignant. Gastroscopy eleven days later showed an irregular ulcer with nodular margins and a white sloughing base on the margin of the angulus. The irregular appearance extended along the lesser curvature below the angulus into the antrum. No peristalsis passed over the lesion. The peristaltic wave was markedly distorted and the antrum was also distorted by this lesion which did not suggest a benign ulcer but which seemed almost certainly malignant. The pathological report was signet ring cell carcinoma.

Comment. In this case, and similarly in the other 6 cases in Group A, gastroscopy gave a more complete description of the lesion than the roentgen ray and also a more positive diagnosis.

Group B. There were 5 cases in this group in which the roentgen report was benign ulcer and gastroscopy raised the question of malignancy. The question of carcinoma was raised by the gastroscopist in 1 case (D H., M.G.H. U No. 236117) because of an almost polypoid mucosa close to the ulcer margin, in another (N.G.M., M.G.H. U No 19511) because of slightly irregular margins and a slightly nodular surrounding mucosa "highly suggestive of malignant infiltration." In a third case (W.J., M.G.H. U No. 422778) the angulus was constantly deformed on the lesser curvature by an ulcerating lesion appearing to be about 2.5 cm. in diameter and 1.5 cm. deep with raised edematous slightly ragged margins and a fairly clean gray base: "from the gastroscopic appearance malignancy must be seriously considered." This case was very important as there was an eight year history of mid-epigastric pain relieved by soda, a perforated ulcer surgically repaired two years before entry, and a roentgenogram showing an ulcer crater 2 by 1 cm.—"most likely gastric ulcer, but I do not believe we can be sure it is not in the duodenum which has been pulled up along the lesser curvature and remains applied to it." In a fourth case (G.E.W., M.G.H., U No. 132669) the gastroscopist believed the ulcer to be malignant because of nodular margins (Fig. 2),

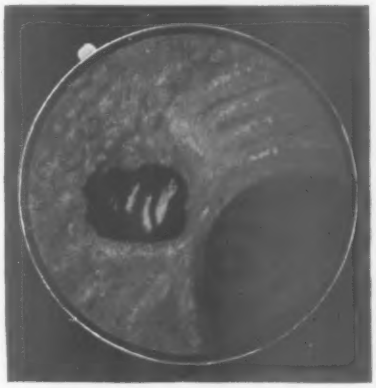

Fig. 2. G.E.W., fourth case in Group B. Gastroscopic appearance of ulcer thought to be benign roentgenologically. The gastroscopist reported probable malignancy because of the nodular margins, dirty base, and surrounding nodular mocosa. The pathological report was adenocarcinoma. (Reproduced through the courtesy of Oxford Medicine.)

dirty base and surrounding nodular mucosa The fifth case in this group is as follows:

Case 9. M. DeF. (M.G.H. U No. 178371). Nine roentgen examinations were made in twenty-two months and malignancy was never mentioned. The first four reports were large gastric ulcer or active gastric ulcer; fifth, crater much smaller; sixth, slight rigidity, crater no longer visible; seventh, lesser curvature markedly shortened, slight irregularity of lesser curvature but definite ulceration is not seen; eighth, no definite evidence of an active ulcer roentgenoscopically; on the roentgenogram there is slight irregularity of the lesser curvature; there is motion on the roentgenogram, whether this is an ulcer cannot be definitely determined; ninth, ulcer on the lesser curvature larger than at the last examination and reaches almost the same size as at the first examination. Lesser curvature in the neighborhood of this ulcer appears somewhat rigid and edematous. Impression: ulcer of the lesser curvature which appears benign by roentgen examination.

Fig. 3. Case 10. The finding from the roentgen examination was reported as showing no definite evidence of tumor or ulcer. In retrospect, however, this was considered to be an error in interpretation for there is certainly a suspicious area high up on the greater curvature. Large carcinoma in this area was readily demonstrated by gastroscopy (see Fig. 4).

Three gastroscopies were performed during a three month period nine months before operation, with the following findings: (1) benign healing ulcer with chronic gastritis; (2) no evidence of ulceration or gastritis; (3) on the lesser curvature at the angulus was a sharply demarcated lesion with slightly gray base 1 cm. diameter, 3 mm. in depth, consistent with benign gastric ulcer but microscopic malignancy could not be positively excluded. Resection advised. Unfortunately, it was nine months before operation was done. The pathological report was carcinoma with metastases to regional lymph nodes, peptic ulceration of the carcinoma and gastritis.

Comment. This case is of very great importance indicating that a peptic ulcer in a carcinoma may apparently heal completely. Nine roentgen reports failed to suggest malignancy. Grossly the lesion looked benign by gastroscopy but the question of malignancy was raised by the gastroscopist on clinical grounds and operation advised.

Group C. There were 5 cases in this group in which the roentgenologist had difficulty in satisfactorily visualizing the lesion due to its location on the greater curvature (2 cases), pyloric obstruction (2 cases), carcinoma close to a stoma (1 case). The following case is an example:

Case 10. P.H. (B.M. U No. 218126). Roentgen examination showed no definite evidence of tumor or ulcer (Fig. 3). Gastroscopy demonstrated an elevated lesion high up on the greater curvature with soft friable margins and questionable ulceration consistent with carcinoma or lymphoma, presumably carcinoma (Fig. 4). The pathological report on the resected specimen was carcinoma with metastases to the regional lymph nodes.

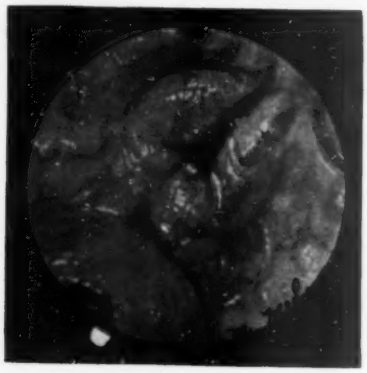

Fig. 4. Case 10. Gastroscopic appearance of large carcinoma of the greater curvature not reported from roentgen examination (see Fig. 3).

Group D.

Case 11. E.V.T. (M.G.H. U No. 341863). Roentgen examination demonstrated a lesion in the lower fourth of the stomach; it appeared to be located within the last 3–4 cm. of the stomach, measured 2 cm. in diameter and was thought to be a small polypoid growth without a stalk. At gastroscopy the pylorus was well seen and on its anterior margin toward the lesser curvature there was a small nodular nipple-like excrescence about 5mm. in diameter and bright red in collor. The lesser curvature appeared irregular, indurated and gave a somewhat hard appearance, as though infiltrated.

There was no peristalsis passing over it. There was one slightly depressed area in this region suggesting an ulceration. The greater curvature and posterior wall were very intense red and glistening, showing evidence of a definite gastritis. The rugae were somewhat irregular and tortuous. The gastroscopic findings were consistent with an infiltrating type of carcinoma and a marked gastritis. The pathologist confirmed these findings including a superficial ulcer—adenocarcinoma, acute and chronic gastritis.

Group E.

Case 12. F. L. (M.G.H., U No. 393564). At roentgen examination the stomach showed a small ulcer at the lesser curvature 1 inch below the cardia. The lesser curvature was not rigid. Peristalsis appeared normal and no filling defects or masses were noted. The findings indicated a gastric ulcer. Gastroscopy revealed multiple polyps; proximal to the angulus on the lesser curvature there was a rather smooth red nodule about 1.5 cm. in diameter and elevated above the mucosa about 1 cm. having the appearance of a polyp. On the greater curvature proximal to the angulus and extending into the upper part of the fundus there were numerous nodules from 0.5 to 1 cm. in diameter. The mucosa elsewhere was somewhat reddened and edematous. The inability of the patient to retain air suggested some rigidity of the gastric wall. The findings were consistent with multiple gastric polyps which were believed to be probably malignant. Because of a nodular liver peritoneoscopy was performed to avoid a laparotomy. Biopsy obtained from a nodule in the liver was reported metastatic adenocarcinoma.

Group F.

Case 13. T P. (P.H. U No. 435396). Roentgen examination showed prolonged delay in the esophagus with narrowing at the lower end but no rigidity. As the stomach filled, a filling defect appeared on the greater curvature opposite the cardiac orifice—no rigidity. After a fifteen minute delay due to the patient's fainting, the stomach appeared to be of normal shape with normal peristaltic activity. Conclusions—spasm of lower esophagus, probable localized gastritis on the greater curvature. Gastroscopy demonstrated an elevated, irregular polypoid mass about 3 cm. in diameter, looking like a small fuzzy cauliflower. It appeared to be high up on the greater curvature toward the anterior wall. The examiner concluded that this was probably carcinoma, or less likely hypertrophic gastritis, and advised transthoracic exploration. This was done and a palliative resection performed. The pathologist reported colloid adenocarcinoma of the cardiac end of stomach with extension into the esophagus and metastases to the regional lymph nodes.

Comment. The differential diagnosis between carcinoma and hypertrophic gastritis may be very difficult or impossible by any method of examination. Perhaps the gastroscopist was lucky in this case, perhaps the roentgenologist would have diagnosed carcinoma on a second examination. It should be emphasized that it is far better to explore a patient and find only gastritis than it is to fail to explore a patient who actually has a carcinoma. In doubtful cases gastrotomy and biopsy should be done.

From the above analysis it is evident that both methods of examination are very important. Where one fails the other may be successful. In 52 out of 125 cases of proved carcinoma one method appeared to be more valuable than the other, the roentgen examination having the advantage by about 3 to 2. Roentgen examination is also an easier and a better established method. The gastroscopist, following the roentgenologist as he almost invariably does, may start with a preconceived idea of the diagnosis, and his observation may be merely confirmatory. Such evidence, however, may be of very great value. On the other hand, it may be a definite handicap to start with a diagnostic prejudice, since it may be erroneous. Besides being confirmatory or otherwise, gastroscopy may add secondary diagnoses such as gastritis with or without erosions or superficial ulcerations. In some cases it may give a more accurate idea of the extent of the lesion.

Carcinoma of the stomach may be classified for our purposes by type and location. The large cauliflower type of tumor is usually readily diagnosed by roentgen examination, and gastroscopic confirmation may

be unnecessary. When, however, such a tumor is located high on the greater curvature in a heavy individual in whom palpation is difficult, or in some cases where there is pyloric obstruction, and other cases where there is distortion from a previous gastric operation, gastroscopy may be the superior method of study. Most of the gastroscopic failures (25 out of 32) were due to mechanical difficulties. In other words, if the gastroscopist can actually get a good view of the lesion the possibility of his being correct is greater than that of the roentgenologist. The latter, however, usually has the advantage in lesions at the pylorus, in the prepyloric area, on the lesser curvature of the antrum, blind area of the fundus, and cases with obstruction at the cardiac orifice. The relative superiority of gastroscopy over roentgenology in differentiating benign from malignant gastric ulcers, when the ulcer is readily visible by both methods, seems to me to be attested by the 12 cases in Groups A and B. In some of these the gastroscopist may have been lucky and in others his clinical judgment may have played a part, for the gastroscopist has a better opportunity than the roentgenologist to get acquainted with the patient and his history. It may be said in passing that since the advent of gastroscopy, roentgen examination of the stomach has consciously or unconsciously received a stimulus which has resulted in more careful roentgenologic technique and more detailed roentgen reports. But we must still not regard the two methods as rivals in any way. In fact, it is amazing how well they supplement each other.

GASTRIC ULCER

Fifty cases of proved benign gastric ulcer have been analyzed as follows: In 16 cases the roentgen ray and gastroscopy were equally correct; in 9 cases equally doubtful; in 21 cases the roentgen examination was superior to gastroscopy, and in 4 cases gastroscopy was superior to the roentgen ray.

As in the cases of carcinoma, the gastroscopic failures were due largely to mechanical difficulties, which accounted for 17 of the 21 cases of superiority of the roentgen examination. Again the mechanical difficulties were chiefly in the prepyloric region (7) and the lesser curvature of antrum (5). It was impossible twice to see ulcers high on the lesser curvature, once near a gastroenterostomy stoma, once the failure was due to excessive secretion and once to spasm of the body of the stomach. In the ulcers well seen by both methods of examination, the roentgen ray seemed superior 4 times, and gastroscopy superior 4 times.

The cases in which the roentgen examination was superior are as follows:

Case 14. S. E. (M.G.H., U No 338066). At the first roentgen examination there was evidence of gastritis, a spastic antrum, and large duodenal cap—no definite filling defect or ulcer crater. Re-examination was requested and was performed later. Meanwhile the gastroscopist reported on the lesser curvature and anterior wall in the antrum of the stomach close to the pylorus an infiltrating and slightly proliferating lesion about 4 to 5 cm. in diameter which was very red and irregular in appearance, some areas being white. The impression was probable carcinoma of the antrum. Re-examination by the roentgen ray was then done and a faintly defined fleck of barium was retained at the lesser curvature about 2 inches from the pyloric valve on the incisura angularis. The general appearance was that of a healing gastric ulcer with a very shallow crater. In concluding his report, the roentgenologist said, "I think it would be practically impossible to determine the lesion in the routine examination and the information gained from the gastroscopy probably made it possible for us to find this lesion."

Comment. This is a generous statement and indicates the good feeling and excellent cooperation between the two departments. In spite of the fact that gastroscopy first localized the lesion, the gastroscopic interpretation was erroneous whereas the roentgen diagnosis was correct.

Case 15. L. B. (M.G.H., U No. 387907). On three occasions in four months the roentgen report was active or healing peptic ulcer grossly benign, located in the mid-portion of the lesser

curvature. This was well seen by gastroscopy as a deep triangular shaped ulcer (Fig. 5) on the lesser curvature of the angulus, about 2 by 0.5 by 0.5 cm. in size. The margins were reddened and slightly irregular, the base a rather dirty grayish pink. The mucosa surrounding the ulcer was markedly nodular and seemed somewhat rigid. Peristalsis was very inactive and did not pass normally over the ulcer. The examiner felt that the ulcer was probably malignant.

Comment. In this case all signs seemed to fail the gastroscopist. The irregular margins, the dirty base, nodular mucosa, rigid wall and abnormal peristalsis should have meant malignancy, but the roentgen report was correct in calling it benign. The pathological report was active benign gastric ulcer with chronic gastritis.

The other 2 cases in this group are quite similar to Case 15: G.H. (M.G.H. U No. 273526) being almost identical, and G.N.K. (M.G.H. U No. 317121) presenting a very similar problem. In the latter case four roentgen examinations were made, all showing one or two ulcers grossly benign. The gastroscopist examined this patient 5 times (the only case in my experience where there have been more gastroscopic than roentgen examinations) making a diagnosis of benign ulcer three times but then leaning toward malignancy because of the nodular mucosa surrounding the ulcers, distortion of peristalsis, failure to heal, short history and absence of free hydrochloric acid. The pathological report was gastric ulcer, marked acute and chronic gastritis. In many such cases there is no doubt surgery is indicated and the question of carrying out the correct procedure is of more importance than making the correct preoperative diagnosis. But in the long run, for the advancement of medicine we must strive for more and more accurate diagnosis by every method available.

There were also 4 cases in this group well seen by both roentgenologist and endoscopist, in which the latter was more accurate.

Case 16. W. B. (M.G.H., U No. 171292). Three roentgen examinations were made during a period of eleven months, each time revealing in the mid-portion of the lesser curvature an ulcer crater 1.0 cm. deep and 1.5 cm. across, with moderate thickening of the gastric wall. At the first examination it was considered grossly benign but with malignant change a distinct possibility. On the second and third examinations it appeared much the same but "should be considered malignant until proved otherwise." The gastroscopist reported an ulcer 1.0 by 1.5 by 0.5 cm. in the mid-portion of the lesser curvature, with a clean gray base and sharp smooth margins having the appearance of a benign gastric ulcer. "The gastroscopic findings point definitely toward a benign ulcer but microscopic malignancy cannot be positively excluded." The pathological report was gastric ulcer, subacute and chronic gastritis.

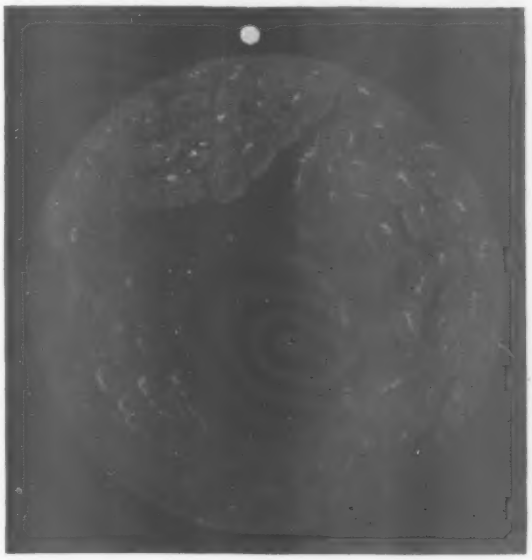

Fig. 5. Case 15. Gastroscopic appearance of ulcer grossly benign roentgenologically but thought to be malignant by gastroscopy because of the irregular margins and the nodular mucosa surrounding the ulcer. The base was described as a rather dirty gray. Moreover, peristalsis did not pass normally over the ulcer. The pathological report, however, was active, benign, gastric ulcer with chronic gastritis. In this case many of the usual signs of malignancy failed the gastroscopist.

Comment. In this case the gastroscopist seemed more definitely in favor of a benign lesion.

Fig. 6. Case 18. First roentgen examination, anteroposterior view, no lesion demonstrable.

Case 17. J.M.M. (M.G.H. U No. 16596). By roentgen examination the distal portion of the antrum was constantly narrowed and slightly irregular. On a second examination, there was a circular narrowing 1.5 cm. in length in the prepyloric area, probably due to a very small neoplasm. At a third examination the previous findings were confirmed—? old ulcer or very small tumor. As frequently happens, the roentgenologist suggested gastroscopy, which revealed a shallow oval ulceration about 1 inch from the pylorus on the lesser curvature—the ulcer had a clean white base and clear cut margins—probably a benign shallow ulcer. This was confirmed histopathologically after resection.

Comment. Although the prepyloric area is often difficult for the gastroscopist the description was very accurate in this case.

Case 18. I.K. (B.M. U No. 44513). Roentgen report: "The stomach was difficult to examine because of its high transverse position and the thickness of the patient. As far as could be determined, however, there were no definite defects in the stomach (Fig. 6). Would like to reexamine—" On the second examination there was found an area of ulceration of the anterior wall (Fig. 7) of the lower stomach, the appearance of which was grossly benign, but malignant changes could not be excluded. Gastroscopy demonstrated two gastric ulcers on the lesser curvature at the angulus. They were about 2 cm. apart, 4 mm. in diameter, 3 mm. deep, with sharp margins and clean gray base. The mucosa surrounding the ulcers was markedly red and edematous, but not nodular or verrucous and not suggestive of neoplasm. Close to the ulcers was a 3 mm. erosion and some fresh blood. Twelve days later gastroscopy was repeated showing one small benign healing gastric ulcer—nothing to suggest carcinoma. Roentgen examination two days after the second gastroscopy could no longer demonstrate an ulcer crater but reported "thickening of the mucosa in this region which could obscure a small crater. This area is extremely difficult to demonstrate by x-ray and I believe that gastroscopy is probably more accurate to determine

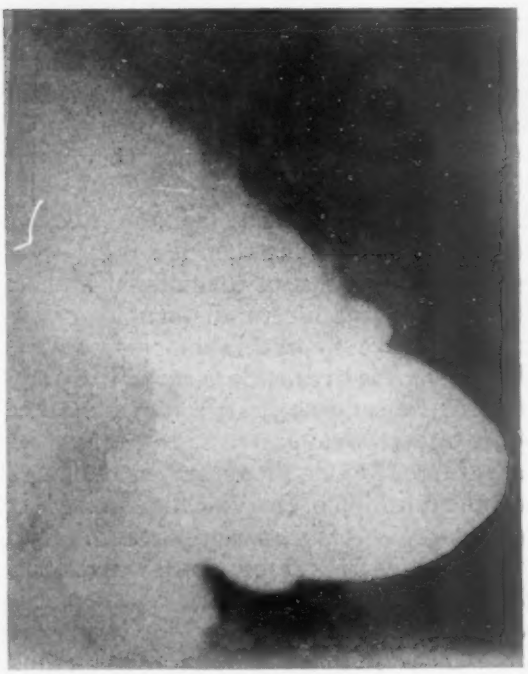

Fig. 7. Case 18. Later roentgen examination showing ulceration of anterior wall grossly benign, malignant changes not excluded. Gastroscopy in this case demonstrated two gastric ulcers on the lesser curvature at the angulus having a benign appearance. The pathologist reported two gastric ulcers with severe gastritis.

the question of regression." About two months later resection was done, and the pathologist reported two gastric ulcers with severe gastritis.

Comment. In this case the gastroscopist was able to demonstrate two ulcers and gastritis instead of only one ulcer. And the roentgenologist was frank in admitting the greater accuracy of gastroscopy.

Case 19. J.M. (B.M. U No. 195485). A man, aged fifty-five, entered the hospital because of severe melena. Roentgen examination showed thickened gastric and duodenal mucosa with a definite deformity of the duodenum and what appeared to be a small ulcer crater on the posterior wall of the duodenum. Roentgenograms which were brought in by the patient showed a much larger crater in this area. Two weeks later reexamination of the esophagus, stomach and duodenum revealed no definite evidence of ulcer. There was practically no deformity of the duodenum. The small intestine was completely examined and showed no pathologic condition. There was a small hiatus hernia. No gastroscopy was done at that time but the patient was explored surgically and no pathologic condition found in the stomach or duodenum. Two weeks after operation gastroscopy revealed a very severe diffuse gastritis with erosions and active hemorrhage. The patient went home, was fairly well for four weeks and then suffered a massive hematemesis. After transfusions and jejunostomy for feeding a partial gastrectomy was successfully performed. The resected specimen showed a very small shallow ulcer on the lesser curvature of the stomach, no more than 3 mm. in diameter. It could not be palpated at the time of operation but it led directly into a large branch of the left gastric artery and it was from that source that the massive hemorrhage had come. There was no ulcer in the duodenum.

Comment. In this case although gastroscopy did not demonstrate the particular ulcer in question it did reveal the stomach as a probable source of the bleeding.

In reviewing these cases of proved gastric ulcer it is disappointing to find how many have not been seen by gastroscopy, but it is really not surprising that many prepyloric and lesser curvature antral ulcers are around the corner or otherwise invisible. Unfortunately, many ulcers are in these relatively blind areas. It behooves us to improve our gastroscopes and our technique. Exclusive of mechanical difficulties, roentgen examination and gastroscopy seem to rate about equally, and each may contribute information of such value that neither examination can be omitted.

DUODENAL ULCER

Since it is impossible to see the duodenum by gastroscopy, the subject of duodenal ulcer is included chiefly because of the associated gastritis. The roentgenologist occasionally reports gastritis associated with duodenal ulcer but frequently does not mention it even if he finds thickened rugae and hypersecretion. The gastroscopist seldom examines the routine case of duodenal ulcer. If he does he will usually find some gastritis. The pathologist, if he examines the stomach histopathologically, always finds more or less gastritis in cases of duodenal ulcer; but unless he is making a special study he may not mention it.

Twenty-five cases of proved duodenal ulcer have had roentgenologic, gastroscopic and pathologic examination. Gastroscopic study is being done less frequently than formerly since it is indicated only under special circumstances. Only 6 of the 25 cases had gastroscopy since 1940; nineteen were done from 1933 to 1939 in an effort to evaluate the method. Pyloric obstruction, where the diagnosis is undetermined by roentgen examination, or in cases where carcinoma seems likely are frequent indications for gastroscopy; similarly unexplained gastrointestinal hemorrhage. Case 19 above is an example of a case thought to be bleeding from duodenal ulcer shown at gastroscopy to have severe gastritis with erosions and proved at operation to have bled from a very small gastric ulcer.

Occasionally, as in Case 3, there will be an eight year history of duodenal ulcer including surgery for a repair of perforation. In this case gastroscopy was very helpful in establishing the presence of a pathologic condition in the stomach in addition to the duodenal ulcer. It was believed to be prob-

ably malignant and was proved at operation to be carcinoma. The history of a proved duodenal ulcer was very misleading.

In duodenal ulcer are the symptoms due to the ulcer or to the associated gastritis? In at least 1 case (E.B., M.G.H. U No. 196632) the ulcer appeared to be healing at roentgen examination but the symptoms were getting worse, due apparently to a very active gastritis shown by gastroscopy. Also in hemorrhage from gastritis in the presence of duodenal ulcer I have raised the question[1,2] as to whether the bleeding is coming mostly from the ulcer, which may be "old" or "healed" or "inactive" according to the roentgen reports, or from the gastritis which may be shown by gastroscopy to be severe with active bleeding.

JEJUNAL ULCER

Eight proved cases of jejunal ulcer have been examined by the roentgen ray and gastroscopy, in 3 of which the methods were equally good, in 2 equally incorrect and in 3 the roentgen ray was superior. There was no proved case of jejunal ulcer in which gastroscopy was superior.

In the 3 cases rated equally good, the jejunal ulcer was satisfactorily seen by the roentgenologist and also by the gastroscopist. In 1 case considered equally incorrect by both examinations, the stoma was well seen by both but no ulcer was visible. The pathologist, however— described shallow irregular ulcer crater at the site of the anastomosis probably too shallow to be seen roentgenologically and probably just around the corner for the gastroscopist. In the fifth case the jejunal ulcer was missed by both the roentgen ray and gastroscopy, the roentgen report describing a duodenal ulcer, normal gastroenterostomy stoma and question of carcinoma near the pylorus. The gastroscopist saw neither the pylorus nor the stoma but described a very nodular lesser curvature, which he thought was probably carcinoma.

The 3 cases in which roentgen examination was superior were due to the mechanical difficulties of gastroscopy, viz. (*a*) stoma not seen at all; (*b*) stoma only partially seen; (*c*) multiple erosions seen on stoma but no ulcer visible.

Therefore, as in carcinoma and gastric ulcer, the mechanical difficulties of gastroscopy are the chief cause of its failure in the diagnosis of jejunal ulcer.

GASTRITIS

I believe roentgenologists, gastroscopists and pathologists would all agree that gastritis is the most common disease of the stomach. It occurs not only in association with ulcer and cancer but also as an independent entity. According to the Department of Radiology at the Massachusetts General Hospital, a diagnosis of gastritis can be made when there is thickening of the rugae and hypersecretion. Schatzki[8] states that such rugae are wider, higher, and more rigid than normal folds; and one cannot make them disappear by pressure. Berg[5] and Schatzki also stress the importance of increased gastric secretion and small round areas of diminished density which are due to particles of mucus. When these findings are present, roentgenologists have usually applied the term "hypertrophic gastritis." I believe this is unfortunate for it implies an ability on their part to differentiate the various types of gastritis—an ability which most roentgenologists admit does not exist. In my opinion, it would be safer under these conditions to say the findings suggest gastritis.

How often is such a diagnosis confirmed by the gastroscopist? A positive diagnosis of gastritis by an expert roentgenologist is usually but not always confirmed by gastroscopy. Occasionally after such a roentgen diagnosis the gastroscopist finds what he considers to be a normal stomach. Frequently he finds superficial gastritis or gastric atrophy instead of the hypertrophic variety. Superficial gastritis as seen gastroscopically corresponds to the acute gastritis described by the pathologist. In such cases the gastroscopist sees increased reddening, edema, and adherent secretion. The path-

ologist finds leukocytes filling the upper portions of the mucosa and a diminution of mucous vacuolization. Cases of superficial gastritis alone (i.e. without other gastric pathology) almost never come to surgery or to autopsy, but it has been possible to correlate the gastroscopic findings in superficial gastritis associated with ulcer or carcinoma with the pathological findings.

Benedict and Mallory[4] carried out such a study in 51 resected specimens and found agreement in two-thirds of the cases of superficial gastritis, two-thirds of the cases of atrophic gastritis. and three-fourths of the cases of hypertrophic gastritis. The gastroscopist and pathologist agree in defining atrophic gastritis as atrophy of large areas of the mucous membrane, seen gastroscopically as a pale, thin mucosa with a network of easily visible blood vessels. Pathologically, the significant feature is the progressive diminution of the epithelial elements, with shortening of the glands and intestinal metaplasia. By "hypertrophic gastritis" the gastroscopist means a mucosa studded with verrucous elevations having a dull surface with few highlights and sometimes a beaded appearance to the rugae. The counterpart of the hypertrophic gastritis described by the gastroscopist appears to be the chronic gastritis which the pathologist recognizes by an exaggeration of the zone of plasma cell infiltration.

The cases studied by Benedict and Mallory were also reviewed from the roentgenologic standpoint by a member of the Department of Radiology who reported roentgen evidence of gastritis in almost every case. He could not differentiate the types of gastritis and made no attempt to do so. The criteria used were thickening of the folds and increased secretion. Pathologically, there is some evidence of gastritis in every case of peptic ulcer or gastric tumor. Therefore one might question the importance of these studies. I believe the significance lies in thus proving the ability of the roentgenologist and gastroscopist to diagnose gastritis not only in association with ulcer or cancer but also as an independent entity, for the diagnostic criteria are the same.

The unquestioned superiority of gastroscopy in differentiating the various types of gastritis is important, for gastritis besides being the most common disease of the stomach is undoubtedly the cause of symptoms. Superficial or acute gastritis is seen in alcoholism, seasickness, airsickness, dietary indiscretion, infectious disease, and in so-called indigestion. It is usually of comparatively short duration and probably 90 per cent of such patients do not need roentgenologic or gastroscopic examination. If symptoms persist, however, it is important from the standpoint of treatment and prognosis to determine whether there is serious gastric disease, acute or chronic gastritis or gastric neurosis. In a series of 1,300 cases examined gastroscopically by Benedict,[3] chronic or hypertrophic gastritis without other gastric or duodenal pathology was found in 117 cases (9 per cent). Pain, vomiting, bleeding, sour eructations and heart burn are frequent symptoms. Pain may be similar to ulcer pain. Hemorrhage from gastritis deserves special mention for very severe hemorrhage can occur from gastritis alone. Some hemorrhage occurred in 42 per cent of the 117 cases. A roentgen diagnosis of gastritis was mentioned in only one-third of the 117 cases. Atrophic gastritis or gastric atrophy may be a late stage of an inflammatory process or may be the result of a deficiency disease such as pernicious anemia, sprue, pellagra, and so forth. It is found commonly with carcinoma, rarely with ulcer. The diagnosis is important, for liver therapy may be specific (Jones, Benedict and Hampton).[6] It is impossible to correlate the thickened folds and increased secretion sometmes reported by roentgen ray with the thin mucosa, absence of folds and lack of secretion seen at gastroscopy. Undoubtedly the gastroscopic diagnosis is more accurate.

Sixteen cases proved pathologically to have only gastritis have been explored surgically, 12 because of the possibility of cancer (Fig. 8, 9 and 10), 3 because of

Fig. 8. W.M. (M.G.H. U No. 409299). The roentgenogram shows polypoid masses in the fundus thought to be polypoid tumor. Gastroscopy showed severe gastritis with ulcers. The pathological report after resection was multiple peptic ulcers, erosions, acute and chronic gastritis.

hemorrhage, and 1 because of the possibility of jejunal ulcer. Five times the two methods of examination seemed equally poor, nine times gastroscopy was considered superior and twice roentgen examination seemed better.

In the 5 cases rated equally poor, 3 were thought to be cancer by both methods; 1 was spasm of the pylorus by roentgen examination, carcinoma of the greater curvature by gastroscopy; and the fifth case was thought to be a large carcinoma of the greater curvature by the roentgen ray, unsatisfactory examination (due to spasm) by gastroscopy.

In 9 cases gastroscopy seemed more accurate than the roentgen examination. In 2 of these (B.D., M.G.H. U No. 334863; A.J., M.G.H. U No. 186668), the roentgenologist reported prepyloric ulcer which was not substantiated pathologically after resection. In both these cases the gastroscopist saw the pylorus and the prepyloric area and could see no ulcer. The gastritis reported by gastroscopy in both cases was confirmed by the pathologist. In a third case (A.R., M.G.H. U No. 300945) the roentgenologist suspected carcinoma or lymphoma of the lesser curvature near the cardia (Fig. 11). In the same area the gastroscopist reported very severe hypertrophic gastritis, which was confirmed by open tube gastroscopic biopsy and also later by exploratory laparotomy and gastrotomy. In 2 other cases (D.V., M.G.H. U No. 57777; E.C.M., M.G.H. U No. 9439), the question of jejunal ulcer or duodenal ulcer was raised by roentgen examination but not found at operation. While the gastroscopist could not exclude these lesions, he did find gastritis which was con-

Fig. 9. J.M. (M.G.H. U No. 355822). Compare with Figure 8. Polypoid lesions of the fundus thought to be due to gastritis. Gastroscopy was reported gastritis. Later resection proved to be carcinoma.

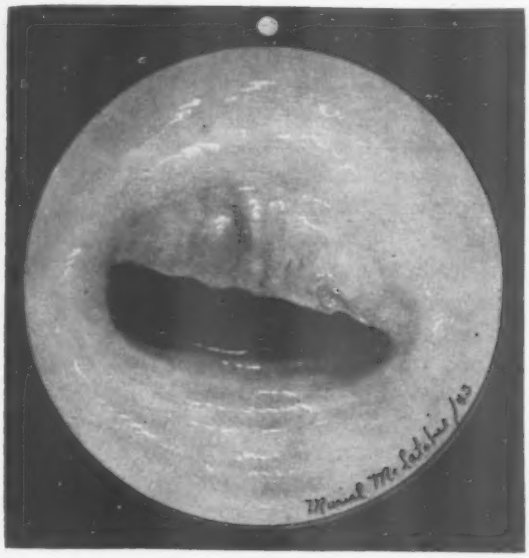

FIG. 10. G.L. (P.M.H. U No. 43-595). Ulcerating carcinoma of antrum readily demonstrated by gastroscopy as shown above but confused with gastritis at the roentgen examination.

FIG. 11. A.R. (M.G.H. U No. 300945). Third case of the 9 cases of gastritis in which gastroscopy seemed more accurate than the roentgen ray. Roentgen appearance is suspicious of carcinoma or lymphoma of the lesser curvature and near the cardia. In the same area, the gastroscopist reported very severe hypertrophic gastritis, confirmed later by open tube gastroscopic biopsy and exploratory laparotomy.

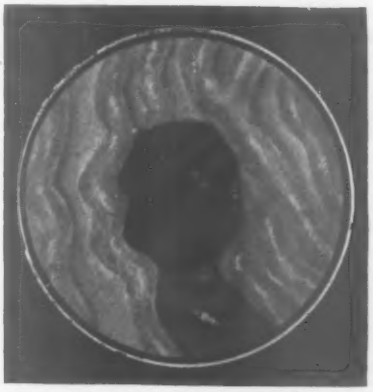

FIG. 12. E.D. (M.G.H. U No. 29583). Sixth case of the 9 cases in which gastroscopy seemed more accurate than the roentgen ray. In this case the roentgenologist was uncertain as to whether he was dealing with foreign bodies or polyps in the stomach with a possible pyloric ulcer or carcinoma. The gastroscopist reported a prune stone and a plum stone with gastritis, as shown in this illustration. Operation confirmed these findings. (Reproduced through the courtesy of Oxford Medicine.)

FIG. 13. C.H. (P.H. U No. 1312). Eighth case of the 9 cases in which gastroscopy seemed more accurate than the roentgen ray. In this case the roentgen report was gastritis, but gastroscopy was far more specific in describing active bleeding from erosions and superficial ulcerations in a severe gastritis. This was confirmed at operation. (Reproduced through the courtesy of Oxford Medicine.)

firmed by the pathologist. In a sixth case, (E.D., M.G.H. U No. 29583) the roentgenologist was uncertain as to whether he was dealing with foreign bodies or polyps in the stomach, with a possible pyloric ulcer or carcinoma; the gastroscopist reported a prune stone and a plum stone with gastritis (Fig. 12). Since the stones failed to pass the pylorus, operation was performed confirming these findings and showing no ulcer or carcinoma. In the seventh case (M.M., M.G.H. U No. 318232) a large carcinoma of the greater curvature was demonstrated roentgenologically but only hypertrophic gastritis was reported by gastroscopy; no carcinoma was found on exploration. The eighth (Fig. 13) and ninth cases (C.H., P.H. U No. 1312; J.E.K., M. G.H. U No. 30620) concerned hemorrhage from postoperative gastritis, in which the roentgen report was gastritis but gastroscopy was far more specific in describing active bleeding from erosions and superficial ulcerations in a severe gastritis.

In 2 cases in this group it seems fair to rate the roentgen ray better than gastroscopy. The first was E.W.(P.H. U No. 129080) in which case the roentgen finding was a localized area of polypoid gastritis, ulcerating neoplasm possible but unlikely; by gastroscopy, however, it was felt the lesion was atypical but consistent with infiltrating neoplasm. A subtotal resection was done, the pathological report being chronic gastritis. The second case (J.S., M. G.H. U No. 283404) was not much credit to either method of examination, the roentgenologist reporting on three examinations old duodenal ulcer, ? ulcer in pylorus, shallow ulcer lesser curvature side of pylorus, small flat ulcer in the immediate prepyloric area, possibly malignant. Gastroscopy was satisfactory and was entirely negative, with no evidence of gastritis. The surgeon did a subtotal resection finding no ulcer. The pathologist found no ulcer or neoplasm, but reported acute and chronic gastritis. On reviewing the roentgenograms the radiologist reported thickening of the folds and increased secretion, indicative of gastritis in his opinion.

It is evident, then, that gastritis may be found by the pathologist when it cannot be detected by the gastroscopist. I know of 7 cases of duodenal or gastric ulcer in which the gastroscopist specifically stated he could see no evidence of gastritis, but some gastritis was found by the pathologist. This is more apt to be true in the antrum than in the body of the stomach, and is best explained probably by the fact that the gastroscopic view is less satisfactory in the antrum. The occasional failure of gastroscopy to diagnose gastritis is probably of no great significance.

In 12 of the 16 cases reported above, the question of a malignant condition was raised. Under such circumstances the difficulty has always been that once either the roentgenologist or the gastroscopist raises the question of neoplasm neither one is willing to exclude it and the patient must then be explored. Even with suitable equipment for endoscopic gastric biopsy, which we do not now possess, positive exclusion of malignancy may still be doubtful owing to the possibility of obtaining tissue from the wrong area.

In spite of the occasional failure of gastroscopy in the diagnosis of gastritis, we have a great deal of pathological evidence of its accuracy and specificity in proved cases of gastritis occurring with or without other gastric disease. Such accurate and specific correlation between roentgenological and pathological findings in gastritis is lacking.

BENIGN TUMOR

Seven proved benign tumors were studied, of which 3 were described pathologically as adenomatous polyps, 1 polyp, 1 polyposis, 1 neurofibroma, and 1 leiomyoma. On three occasions roentgen examination and gastroscopy seemed about equal twice the roentgen ray was better, and twice gastroscopy was better.

Three times roentgen examination and gastroscopy were about equally good,

doubtful or incorrect: once (I.S.C., B. M. U No. 160436) both methods were roughly correct in describing multiple polyps, ? malignancy; a second time (A.A., M.G.H., U No. 187961) both doubtful in describing a large pedunculated tumor mass in the antrum probably malignant; and in the third case (E.C.T., P.H., U No 33749) both incorrect as a 1 cm. leiomyoma of the body of the stomach was thought to be scirrhous carcinoma of the pylorus at roentgen examination and was not seen at all by gastroscopy.

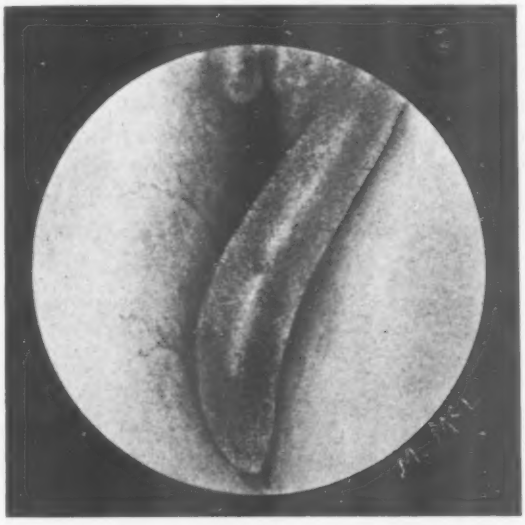

FIG. 14. E.S. (M.G.H. U No. 6073). Gastroscopic appearance of long smooth polypoid lesion of antrum probably benign, thought to be carcinoma by roentgen examination. This proved to be a long finger-like benign polyp. (Reproduced through the courtesy of the *New England Journal of Medicine.*)

Roentgen examination was definitely superior in 2 cases: (1) (A.I.B., M.G.H., U No. 218777) reporting very accurately an oval lesion on the greater curvature of the antrum, possibly leiomyoma or early carcinoma. This lesion proved to be an adenomatous polyp and was not seen at all by gastroscopy; (2) (M.K., P.H., U No. 206463) roentgen ray reported one or more polyps in the lower stomach on the greater curvature but these were not visible by gastroscopy. The pathological report was benign adenomatous polyp on the greater curvature 7 cm. from the pylorus. In these 2 cases the superiority of the roentgen examination was due to the mechanical difficulties of gastroscopy.

FIG. 15. J.E.S. (P.H. U No. 270243). Gastroscopic appearance of a submucosal tumor thought to be benign by gastroscopy. The pathological report was neurofibroma. Roentgen examination at another institution had reported this as carcinoma (see Fig. 16). (Reproduced through the courtesy of Oxford Medicine.)

Twice gastroscopy was more accurate than the roentgen examination: once (E.S. M.G.H., U No. 6073) describing a long smooth polypoid lesion (Fig. 14) of the antrum probably benign, whereas it was thought to be carcinoma roentgenologically. This proved to be a long finger-like benign polyp. In the other case (J.E.S., P.H., U No. 270243) the roentgen examination in another city described a carcinoma of the antrum, gastroscopy reported a submucosal tumor with a small ulceration on it (Fig. 15). After the gastroscopy another roentgen examination revealed an intramural tumor (Fig. 16). The pathological report was neurofibroma.

It is evident from these 7 cases of benign tumor that the chances of error are fairly large and that we come closer to the correct diagnosis if both methods of examination are used, especially when they are used in close cooperation with each other.

Fig. 16. Roentgen appearance of lesion shown in Figure 15. This roentgenogram was taken following gastroscopy and confirmed the gastroscopist's opinion. The first roentgen report in another institution had been carcinoma.

LYMPHOMA

Five cases of proved lymphoma have been studied roentgenologically and by gastroscopy. In 3 cases the lesion seemed to be quite typical of carcinoma by both methods of examination. In the fourth case (N.I., M.G.H., U No. 314994) the roentgenologist reported a lesser curvature lesion consistent with a 1 inch saddle ulcer associated with an unusual type of gastritis. This happened to be the first case in the United States examined by the flexible gastroscope (April 6, 1933), and no definite conclusions were reached. The fifth case (P.B., M.G.H., U No. 289112) was the only one in which lymphoma was mentioned by either method of examination. During a seven month period the roentgenologist studied this patient eight times. On the first examination he described a large ulcer at the posterior wall of the fundus, possibly benign or malignant, lymphoma to be considered (Fig. 17). On seven subsequent examinations he described marked swelling of the folds on four occasions, with no ulcers twice and two or three grossly benign ulcers at other times. The question of malignant ulcer of lymphoma was mentioned only on the first examination. During the same period the gastroscopist made six examinations concluding successively as follows: (1) multiple gastric ulcers and erosions with hemorrhage; severe superficial and hypertrophic gastritis (Fig. 18); neoplasm not excluded; advise House admission; (2) very suspicious of carcinoma; exploration should be done unless the Department of Radiology excludes malignancy; (3) very severe hypertrophic gastritis, probably not malignant; (4) extremely severe hypertrophic gastritis with multiple gastric ulcers on the greater curva-

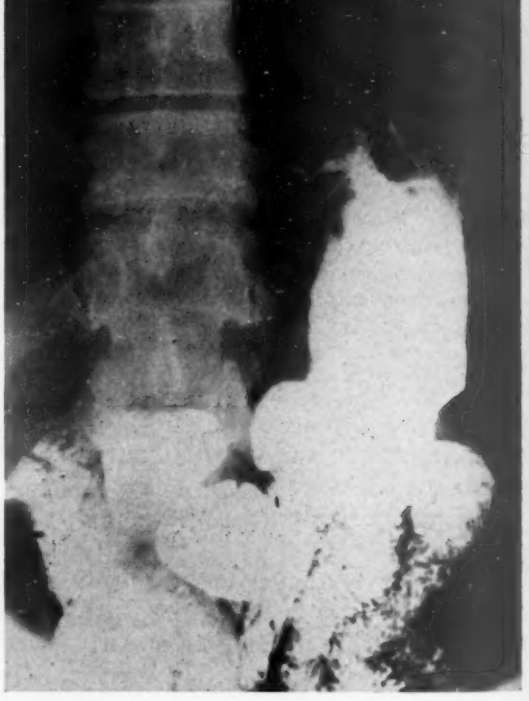

Fig. 17. P.B. (M.G.H. U No. 289112). Roentgen appearance showed very thick folds in the fundus. Lymphoma was mentioned as a possibility on one of eight examinations. Pathological report malignant lymphoma (see Fig. 18).

ture—neoplasm a possibility; (5) unsatisfactory due to spasm and secretions—"because of repeated occurrences of ulceration in various parts of the stomach, I believe radical resection will be inevitable;" (6) erosions and clots of blood on greater curvature but no ulcer demonstrable—very severe hypertrophic gastritis with erosion and hemorrhage. "I still believe that partial gastric resection will be inevitable." The pathology report was malignant lymphoma lymphocytic type, with peptic ulceration.

In considering these 5 cases of lymphoma it seems that at the present time the best we can hope for is to suspect it occasionally as in the last case. The roentgenologist based his suspicion on unusually thick rugae which he said were "possibly due to hypertrophy but there was a possibility also that the thickened rugae may represent lymphomatous infiltration." On seven subsequent examinations, however, he mentioned neither carcinoma nor lymphoma. In five out of six gastroscopies the question of malignancy or surgery was raised.

The diagnostic criteria to look for in lymphoma may be unusually thick rugae, very marked cobblestone mucosa, multiple erosions and ulcerations in various parts of the stomach at different times, with or without rigidity or a tumor mass. With further experience in both roentgen examination and gastroscopy, correct diagnosis may be possible.

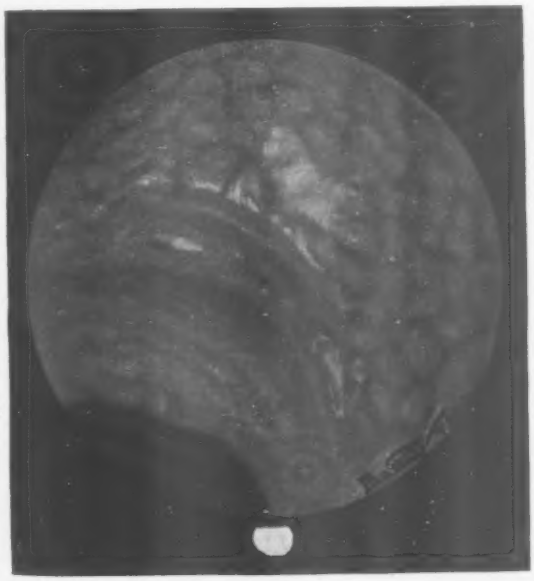

Fig. 18. P.B. (M.G.H. U No. 289112). Gastroscopy demonstrated multiple gastric ulcers and erosions with hemorrhage. The marked cobblestone appearance led to a gastroscopic diagnosis of hypertrophic gastritis. Neoplasm, however, was suspected but lymphoma was not specifically mentioned. The pathological report was malignant lymphoma, lymphocytic type, with peptic ulcerations. (Reproduced through the courtesy of *Surgery, Gynecology & Obstetrics.*)

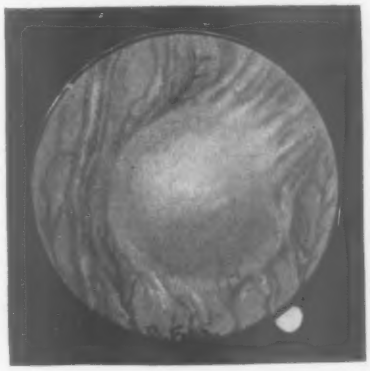

Fig. 19. E.L. (M.G.H. U No. 279061). In this case of proved neurogenic fibrosarcoma, the roentgenologist reported a 7 by 5 cm. mass arising from a broad base—first choice leiomyoma, much less likely carcinoma. The gastroscopist described a smooth lesion as seen in this illustration with no visible ulceration—probably benign leiomyoma or neurofibroma. Neither method of examination made the correct diagnosis.

SARCOMA

Only 2 cases fall in this group, both of which were proved histopathologically to be neurogenic fibrosarcoma. In the first case (G.W.W., M.G.H. U No. 328837), the roentgenologist demonstrated a constant 3 cm. concave pressure defect on the lesser curvature near the angularis, very suggestive of a mural tumor. Unfortunately, this tumor was not seen by gastroscopy (another very early case in the career of the gastroscopist, April 29, 1933). In the other

case (E.L., M.G.H., U No. 279061), the roentgenologist reported a 7 by 5 cm. mass arising from a broad base of the lesser curvature and posterior wall of the fundus of the stomach (Fig. 19). The surface was rather smooth with one slight lobulation and one deep ulceration: first choice, leiomyoma; second choice, much less likely carcinoma. The gastroscopist described a smooth rounded submucosal tumor with

Fig. 20. E.S. (P.H. U No. 296104). Gastroscopic appearance of smooth rounded mass projecting from the lesser curvature and posterior wall of the antrum thought to be a benign tumor by gastroscopy but proved at operation to be carcinoma of the pancreas invading the wall of the stomach submucosally (see Fig. 21).

no visible ulceration—probably benign leiomyoma or neurofibroma.

Since the benign neurofibroma previously described was also slightly ulcerated it would seem that there may be no way of differentiating a benign from a malignant intramural tumor. In the malignant case, however, the tumor was larger and the ulceration deeper. Further roentgenologic and gastroscopic experience will be important.

METASTATIC CARCINOMA

In 3 cases a carcinoma of the pancreas was proved at operation to have invaded the wall of the stomach. In the first case (M.B., M.G.H. U No. 270419), the roentgenologist found definite rigidity along the lesser curvature of the body of the stomach and made a diagnosis of a malignant lesion, probably carcinoma, involving a large portion of the body of the stomach. On gastroscopy the instrument met complete obstruction about 2 cm. inside the cardia; this obstruction was thought to be probably due to neoplasm but no satisfactory view was obtained. In the second case (D.J.McC., M.G.H. U No. 332957), roentgen examination showed marked deformity of the antrum, pylorus and duodenal loop probably from extrinsic involvement, but carcinoma of the pancreas could not be diagnosed. Gastroscopy demonstrated normal mucosa and rugae throughout. In the third case (E.S. P.H., U No. 396104), several preliminary roentgen examinations at an outside hospital demonstrated a normal stomach. Gastroscopy, however, revealed a constant smooth mass about 3–4 cm. in diameter covered with normal mucosa, projecting from the lesser curvature and posterior wall of the antrum (Fig. 20). It was not ulcerated and peristalsis appeared to pass smoothly over it. It was thought to be a benign tumor—neurofibroma or leiomyoma. Roentgen examination later confirmed this filling defect without ulceration and concurred in the opinion that it was likely to be a neurofibroma (Fig. 21).

In none of these cases did either method of examination make the correct diagnosis, yet each contributed something in each case. In the first case, both methods revealed an abnormality, the roentgen examination being more specific but incorrect nevertheless. In the second case, the roentgen ray was more valuable, demonstrating a lesion that was probably extrinsic, gastroscopy confirming a normal gastric mucosa. In the third case the gastroscopist first demonstrated a gastric lesion, in the face of negative roentgen findings, but his conclusions as to the diagnosis were incorrect.

NORMAL STOMACH

Four patients in this series have been explored because of the possibility of carcinoma but no gastric lesion was found.

Case 20. R.B. (M.G.H. U No. 53367). Five roentgen examinations were done over a period of six months, the first being inconclusive but suggesting a deep ulcer crater in a carcinoma, the second, third and fourth failing to demonstrate a carcinoma, but the fifth showing a "large irregular filling defect at fundus of stomach." Two gastroscopies were done and showed gastritis but no tumor. Surgical exploration revealed no gastric abnormality.

Comment. The stomach was not opened and a small soft tumor or gastritis might therefore have been overlooked, but roentgen examination nine months later was negative for tumor though it did show some increase in the size of the rugae.

Case 21. W.D. (M.G.H. U No. 37616). The roentgenologist studied this patient on three successive days, demonstrating marked swelling and slight irregularity of the rugae in the upper half of the stomach, more likely a diffusely growing neoplasm than a localized hypertrophic gastritis. The gastroscopist demonstrated superficial gastritis and an irregular, slightly elevated area bout 1.5 inches below the cardia, near which there was a papillary nodule, consistent with early carcinoma. Exploratory laparotomy with gastrotomy revealed no evidence of carcinoma. Biopsy of the gastric mucosa was reported normal stomach.

Comment. Both examiners suspected a carcinoma which was not found at operation. Histopathologically there was not even any gastritis, though the house officer assisting at the operation reported "considerable hypertrophic gastritis." Naturally one would question such an observation and one would also wonder from exactly what area the biopsy was taken.

Case 22. M.O. (M.G.H., U No. 289057). Several roentgenograms and one gastroscopy were negative in this case. Exploration was done, however, because of a previous laparotomy at another hospital three months before admission, at which time, a small, fairly well circumscribed mass was found on the anterior wall of the stomach near the pylorus. Biopsy of this mass at that time was reported as a slowly growing adenocarcinoma. At the second exploration there was a rather firm tumor adjacent to the lesser curvature and posterior wall of the stomach and probably arising from the stomach. Resection was performed, the pathology report being ectopic pancreas in duodenum.

Fig. 21. Roentgen appearance of lesion shown in Figure 20. The first roentgen examination made in another city had been reported as normal stomach. Roentgen examination after gastroscopy confirmed the filling defect without ulceration and the roentgenologist felt that it was probably a neurofibroma. In retrospect, however, the roentgenologist felt that the diagnosis of carcinoma of the head of the pancreas could have been made because of the extrinsic pressure on the second portion of the duodenum as shown in this illustration.

Comment. The roentgenologist and gastroscopist were both correct in reporting no disease of the stomach.

Case 23. J.O. (P.M.H. U No. 41-100). In this case two roentgen examinations were reported as showing an irregular gastric outline near the cardiac orifice for a distance of about 4 cm. and a diagnosis of carcinoma involving the cardiac orifice was made. Gastroscopy was

done by the straight rigid open tube method and no tumor was visible at the cardia or in the upper stomach. A biopsy was obtained which was reported as normal gastric mucosa. In order to be absolutely certain, the patient was explored surgically by the transthoracic route and no tumor was found Roentgen examination two and a half years later showed only slight cardiospasm and normal stomach.

In the above 4 cases the roentgen examination and gastroscopy were equally correct in demonstrating no disease of the stomach in Case 22, and about equally incorrect in suspecting a non-existent carcinoma in Case 21. In Cases 20 and 23 the roentgenologist diagnosed carcinoma which was in fact not present, and which had been ruled out as far as possible by gastroscopy. In these 2 cases, therefore, the gastroscopist was correct and the roentgenologist incorrect, but, as previously stated, the exclusion of a gastric neoplasm by any method cannot be absolutely positive.

DISCUSSION

It seems fairly obvious that both the roentgen examination and gastroscopy occupy a very important place in the diagnosis of gastric disease. It has already been admitted that evaluation of the relative merits of the two methods is somewhat arbitrary. It is also unfair because they are so different and work so well to supplement each other. Theoretically such a comparison should not be attempted but practically it is helpful to know where we stand and in what types of gastric disease we can expect the best results from each method. Some of the gastroscopic errors made ten years ago were due to inexperience and would not be made today. There has also been an improvement in roentgen examination of the stomach, notably by the use of the relief technique and spot roentgenograms. It is quite clear from the above analysis of cases that by the judicious use of both methods greater diagnostic accuracy can be obtained than by the use of either method alone.

Gastroscopy is indicated in cases of gastric pathology where the diagnosis is in doubt. Patients with hematemesis or melena may have negative roentgen findings; gastroscopy may show the cause of the bleeding to be a severe gastritis with erosions and superficial ulcerations. Serious hemorrhage may come from such a gastritis in the absence of other pathologic condition. Similarly patients with an otherwise unexplained anemia may be found by gastroscopy to have gastric pathology. Lesions of the lesser curvature may be benign or malignant; the differential diagnosis may be impossible by roentgen examination. In such cases the gastroscopist may be able to make a positive diagnosis. When the question arises as to medical or surgical treatment in a given case, gastroscopic examination may definitely swing the balance one way or the other. Cases of pyloric obstruction or pylorospasm may be impossible to diagnose roentgenologically; such cases should be studied by gastroscopy, for in some of them the gastroscopic diagnosis is comparatively easy. So it goes, one method supplementing the other. Cases difficult to diagnose by gastroscopy may be easy roentgenologically, and vice versa. Lesions high up on the greater curvature may be hard to palpate and visualize by the roentgen ray; such cases should have gastroscopy, for usually this area is easy to see with the gastroscope. On the other hand, small lesions close to the pylorus, on the lesser curvature of the antrum, high on the lesser curvature of the body, and high in the fundus may be impossible to see by gastroscopy but easy to see roentgenologically. The differential diagnosis of hypertrophic gastritis and carcinoma may be impossible, but gastroscopy should be done as it may be quite definite in determining the course to pursue. Finally, many patients have gastrointestinal symptoms with repeatedly negative roentgen findings; such patients may be erroneously classified as gastric neurotics until gastroscopy reveals gastritis.

Excluding duodenal ulcer we are dealing in this report with 220 cases of gastric disease in which there is a positive pathological diagnosis. Analysis of these cases shows the roentgen examination and gastroscopy equally correct in 88 (40 per cent); equally doubtful in 14 (6 per cent); equally incorrect in 17 (8 per cent); roentgen examination superior in 63 (29 per cent); gastroscopy superior in 38 (17 per cent). In 50 cases (21 per cent) the failure of gastroscopy was attributable to the mechanical difficulties of instrumentation, with consequent inability to properly visualize certain parts of the stomach. If these could be overcome the superiority of the roentgen examination would be reduced from 63 cases to 13 (6 per cent) as against the 38 cases (17 per cent) in which gastroscopy was more accurate. This would appear to indicate that if the gastroscopist obtains a satisfactory view of the lesion he has a better chance than the roentgenologist of making a correct diagnosis. The finding of 31 cases (14 per cent) where both methods were equally doubtful or incorrect is somewhat disturbing and indicates that our diagnostic methods leave much to be desired. Fortunately, clinical judgment has not been entirely forgotten in these days of scientific advancement and the wise physician will assemble the available data and usually arrive at the proper medical course or surgical procedure.

CONCLUSIONS

Two hundred and forty-five cases of proved carcinoma, gastric ulcer, duodenal ulcer, jejunal ulcer, gastritis, benign tumor, lymphoma, sarcoma, metastatic carcinoma of the stomach wall, and normal stomach have been studied in an attempt to correlate the roentgen and gastroscopic findings in each case with the known pathologic diagnosis.

Although it is unfair to compare the roentgen examination with gastroscopy, since the latter supplements the former and is in no way competitive, it can be stated that in certain instances the roentgen examination appears to be superior to gastroscopy, and in other cases gastroscopy appears to be superior to the roentgen ray.

The roentgen examination and gastroscopy were about equal in 54 per cent of the cases, roentgen examination was considered superior in 29 per cent, gastroscopy superior in 17 per cent.

The chief causes of failure in gastroscopy are mechanical. If mechanical difficulties could be eliminated the number of cases in which the roentgen examination appears to be superior to gastroscopy would be reduced to 13 (6 per cent) as against the 38 cases (17 per cent) in which gastroscopy seemed more accurate.

From this analysis it appears that if the gastroscopist can get a satisfactory view of the lesion his chances of reaching a correct diagnosis are greater than those of the roentgenologist.

Gastroscopists must therefore strive to bring about improvements in the gastroscope so that blind areas may be eliminated and biopsies easily taken.

Greater diagnostic accuracy is attainable when both methods are used cooperatively than when either method is used alone.

The proper procedure for the patient is all-important and to this end there must be close cooperation between the clinician, roentgenologist, gastroscopist and pathologist.

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VOL. 55, NO. 3

SPONDYLOLISTHESIS

CRITERIA FOR MORE ACCURATE DIAGNOSIS OF TRUE ANTERIOR SLIP OF THE INVOLVED VERTEBRAL SEGMENT*

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SPONDYLOLISTHESIS is a well known and fairly common disorder, which has assumed increasing importance in recent years in connection with the care and disposition of military and industrial personnel, especially of those claiming disability from lumbosacral backache. The incidence in the ordinary population is quite low (perhaps 5 per cent of adults), but in large general hospitals, especially those handling Army and Naval personnel, its incidence is comparatively high (as much as 10 per cent of "low back" cases referred for roentgen examination).

The recognition of advanced spondylolisthesis in middle aged and elderly persons, especially women, is relatively simple, and the diagnosis may often be made clinically. Indeed, the first reported cases were discovered as obstetrical problems (shortened true conjugates).[16] Moderate and even slight degrees of slip may sometimes be correctly diagnosed by the alert orthopedist. However, the diagnosis of minimal degrees of spondylolisthesis in early cases is usually difficult, and often complicated by the fact that, while the posterior margin of the fifth lumbar body may appear to be displaced forward, its anterior margin may be found in normal alignment with the margins of the adjacent bodies. This may be due to the presence of a congenitally foreshortened fifth lumbar body, and the problem then arises as to which surface of this body should be regarded as the criterion for estimating displacement, the anterior or the posterior surface. It is in an attempt to clarify this point that the present study was undertaken.

TERMINOLOGY

Spondylolisthesis (*spondylos*, a vertebra; *olisthesis*, to slip) is defined as anterior displacement of a vertebral body with solution of continuity of its posterior arch. Strictly speaking, the displacement usually involves the body plus its transverse processes, pedicles, superior articular processes, and adjacent ventral portions of the laminae. The solution of continuity in the arch is nearly always bilateral and usually consists of *slender fissures in the interarticular portions* of the neural arch. This is the common type of spondylolisthesis, and may be termed true spondylolisthesis. It can occur almost anywhere in the spine but is most common in the lower lumbar area, involving usually the fifth or last lumbar segment.

There are various other types of displacement and change in this area which do not fit strictly into the classification of true spondylolisthesis, but which are sometimes confused with it. These include:

(a) *Anterior dislocation of a lower lumbar vertebra*, a fairly rare condition associated usually with fractures of the articular processes of this or the adjacent segments, but sometimes associated with simple luxation of the posterior articulations of the involved segment. These fractures or dislocations may be on a traumatic or pathologic basis (inflammatory disease, metastatic neoplasm, degenerative osteoarthritis with erosion of facets, etc.).

(b) *Elongation of a lower lumbar body* (localized platyspondyly). The body is elongated in the sagittal plane and its anterior (or posterior) margin projects in front of (or behind) the normal zone, but the neural arch is not defective. The elongation may be congenital or acquired.

(c) *Foreshortening of a lower lumbar body* (localized brachyspondyly). The body is foreshortened in the sagittal plane; its an-

* The opinions and views set forth in this article are those of the writers, and are not to be considered as reflecting the policies of the Navy Department.

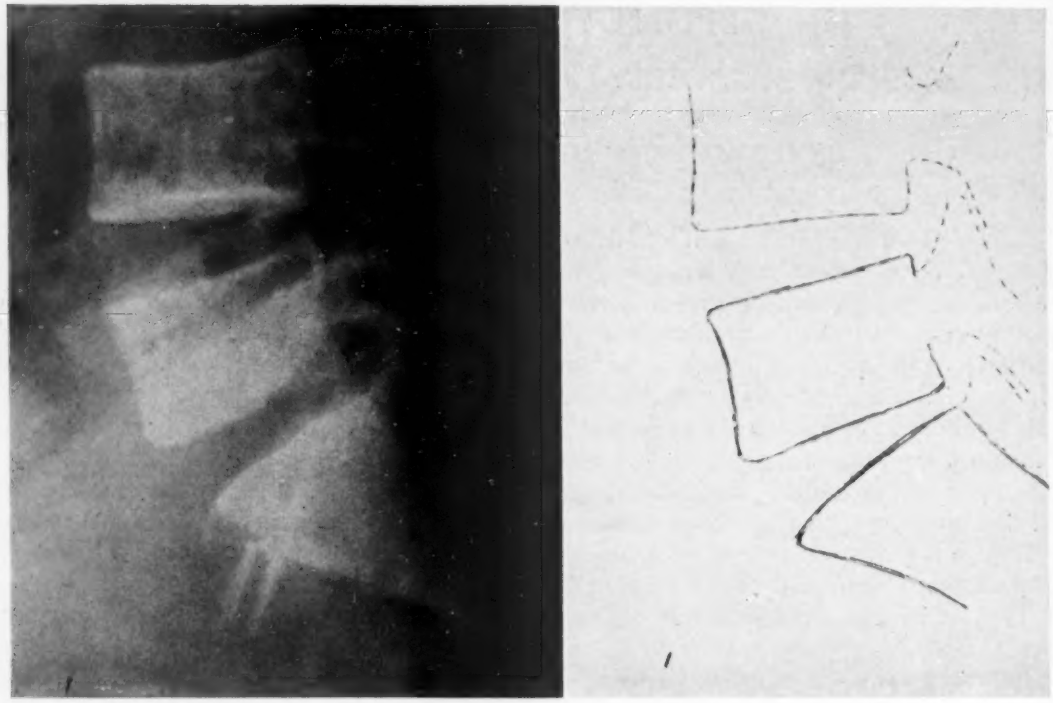

Fig. 1. Normal "*rectangular*" type of fifth lumbar body. When the body is of this shape, the detection of true slip is much simpler than when it is caudally foreshortened (hatchet shaped) or otherwise unusual in shape. The term "rectangular" is a relative one, since when measured, most fifth lumbar bodies that appear to be rectangular in lateral projections are found to be slightly wedge shaped, the vertical dimensions of their posterior surfaces being from 2 to 8 mm. less than the vertical dimensions of their anterior surfaces.

terior margin may be in normal alignment with those of its fellows, but its posterior margin is from 1 to several millimeters ventral to that of the subjacent segment, and sometimes ventral to that of the superjacent segment also. In addition to being foreshortened, these bodies are often wedge or hatchet shaped. There may or may not be interarticular defects in the neural arch of the involved segment. When there are, these cases are often erroneously labeled "spondylolisthesis grade 1," when in fact, no true slip has occurred. Once labeled such, these cases tend to become progressively symptomatic. They or their attendant family physician, seeing the word spondylolisthesis applied to their simple anatomic lesion, may conjure up the clinical description of the disorder seen in some orthopedic textbooks:

A dimple appears in the back at the lumbosacral junction; the umbilicus seems very near the symphysis, and the arms of the individual appear to be extra long. This displacement may lead to severe pain in the back, sacro-iliac regions, thighs and feet. The roentgenograms may show in the lateral view the body of the fifth lumbar rotated well down in front of the sacrum.*

In addition to "true" and "false" spondylolisthesis, there are two other terms used somewhat loosely for conditions in this area. These are "prespondylolisthesis" and "reverse spondylolisthesis."

Prespondylolisthesis is mentioned only to be condemned. It is a fearsome word, philologically and psychologically, applied to a condition in which there are interarticular defects in the neural arch of a vertebral

* Speed, Kellogg. A Text-Book of Fractures and Dislocations Covering Their Pathology, Diagnosis and Treatment. Fourth edition. Lea & Febiger, Philadelphia, 1942, p. 232.

segment with no forward displacement of the anterior portion of that segment. The term is unwise because it implies that subsequent slipping of the body is almost inevitable, and it is confused in the minds of many physicians and patients with the true entity. It may unfairly restrict or prevent proper employment of an individual, and result in considerable mental as well as economic hardship to him and his family. Some authors use the word "spondylolysis" for the condition. We believe that the term "neural arch defects without visible slip of body" is clearer and preferable.

Reverse spondylolisthesis is also mentioned to be condemned. The complex term is applied to a condition in which a vertebral body lies or appears to lie on a plane dorsal to that of its fellows. It is rarely or never due to interarticular defects in the neural arch, nor associated with true to-and-fro slipping. If actually present, it is usually a fixed condition, secondary either to anomalous development of the articular processes or bodies, or to bizarre disease or trauma of the same. A foreshortened first sacral body may cause the last lumbar segment to have this appearance.

ETIOLOGY

The cause of the forward slipping of the involved vertebral segment (along with the superjacent spinal column) is presumed to be the normal stress of weight of the body, in some instances combined with occupational strains, trauma, weakening of muscles and ligaments from age or disease, and softening of some of these structures from pregnancy—all in the presence of a vertebral segment with a defective neural arch.

The cause of the defects is still unknown, in the majority of instances. It was first believed that they were *traumatic* in origin.[8,16] Then, especially because they were smooth and symmetrical, a *congenital* origin was postulated.[6,8] For various and valid reasons anatomists cast some doubt on this hypothesis, and returned to a

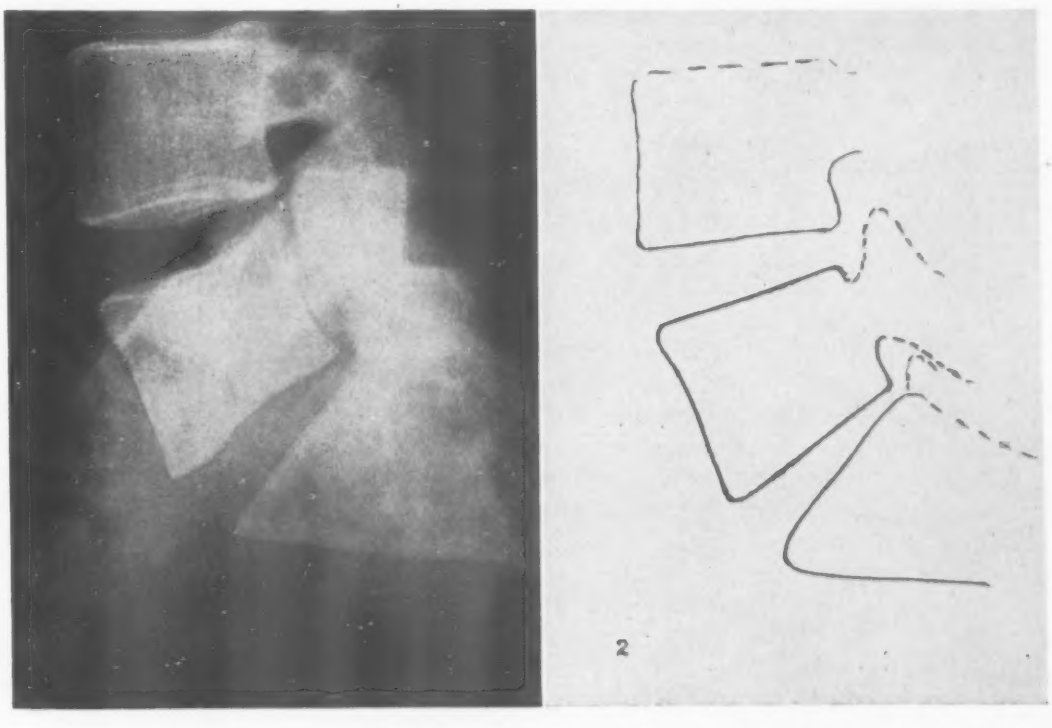

Fig. 2. "*Wedge-shaped*" fifth lumbar body. Horizontal type of sacrum. Note that the fifth lumbar body is not foreshortened (retouched).

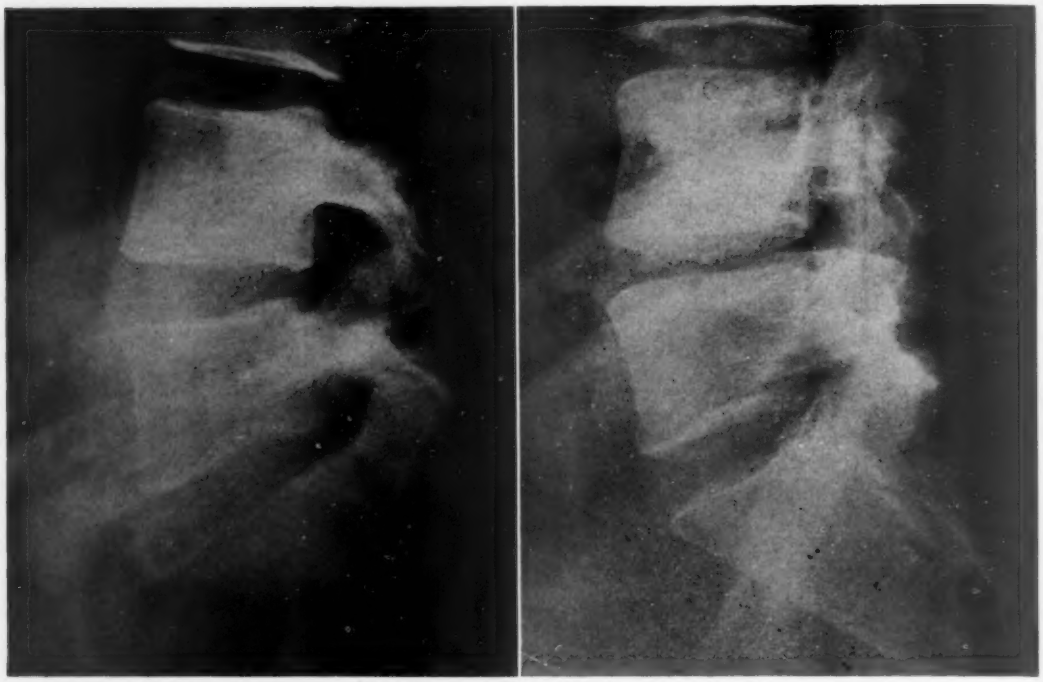

Fig. 3. "*Hatchet-shaped*" fifth lumbar body. This type is commonly foreshortened caudally, and often results in an appearance suggesting slight spondylolisthesis. There is a second type of hatchet shape in which the body is foreshortened at its upper or cephalic end; this is rare and not a source of confusion in the diagnosis of slip.

Fig. 4. Caudally foreshortened fifth lumbar body. This is the type which may result in an erroneous diagnosis of spondylolisthesis when neural arch defects are present.

traumatic explanation—infantile or birth traumata with actual fractures or local osteochondral vascular disturbances of the neural arch.[1,8,9] Some are undoubtedly due to adolescent or adult injuries of an unusual type. It is conceivable to us, but naturally very difficult of proof, that *strain or deficiency* fractures may explain many cases, especially in the presence of suitable anatomic conditions. The latter would include a congenitally slender isthmus plus a poor blood supply. The critical nature of the blood supply to the neck of the femur is well known. It is quite possible that in some individuals the vascular supply of the interarticular areas of the neural arches of the lower lumbar vertebrae is equally critical. If so, this would explain the failure of fractures in these areas to unite readily, and hence the permanent clefts.

PATHOLOGIC CLASSIFICATION

The pathology may be considered under four stages: minimal, early, moderate and advanced. Most of the cases we have seen in the last two years in Naval Hospitals are classifiable as *minimal*. Many of these have been discharged from service; some returned to duty, often limited duty.

These minimal cases show a defect in one or both halves of the neural arch (usually both) of a lower lumbar vertebral segment. The posterior one-third of the segment is retained in more or less normal alignment (by the various spinal ligaments attached thereto, the capsular, interspinous, and supraspinous ligaments). The anterior two-thirds of the segment show a forward displacement of 1 or 2 mm., sometimes increasing in the erect position* or with heavy

* Some authors stress that recumbent lateral projections should be made with the legs *extended*, instead of the usual slightly flexed position. After making projections in both poses in a series of cases, we abandoned the extended one because (*a*) there was no

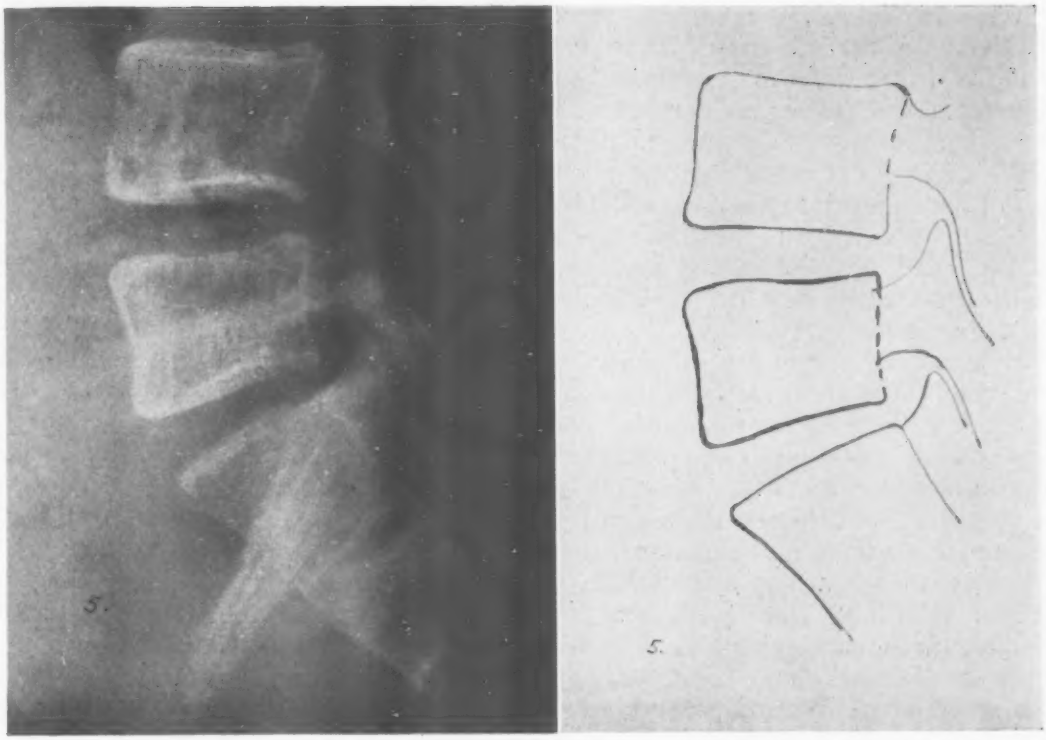

FIG. 5. Generally foreshortened fifth lumbar body. This type also leads to an erroneous diagnosis of spondylolisthesis. Its posterior surface lies on a plane anterior to that of the first sacral, but its anterior surface is not truly displaced. Note that the sacrum is of the vertical type.

weight bearing. There may be slight posterior narrowing of the subjacent intervertebral disc. There are usually no osteophytes on the anterior superior margin of the subjacent vertebral body, nor sclerotic changes in its superior horizontal surface.

When the arch defect is unilateral, the involved body may, if it slips at all, rotate slightly to the unaffected side, rather than forward; this we have seen only once.

In addition to the cleft or clefts in the neural arch, there may be one in the spinous process; one or more of the articular processes may be aplastic, and other anomalies may be present. Incidentally, such associated findings, when present, have lent support to the hypothesis of a congenital origin for the interarticular defects, despite anatomists' objections that there is no developmental reason for them.

The arch defects may involve *two* adjacent lumbar segments in a strikingly similar manner—smooth, slender, oblique fissures in the interarticular portions of the fourth and fifth lumbar segments, or other adjacent segments, without associated evidence of trauma.[4,13,19]

At the other end of the pathological scale are seen the advanced cases, as first described by Killian[10] in 1853*, and beautifully illustrated in the classical monograph of Neugebauer[16] in 1882. The advanced cases show marked forward displacement and sometimes downward tilting of the in-

significant change in the lumbosacral angle in most cases and (*b*) motion was difficult to eliminate in extension. Other authors stress that *erect* lateral projections should be made as a routine; such erect views are of value in demonstrating gliding in some cases, but are really *necessary* only in cases with established arch defects and *questionable* slip.

* The term spondylolisthesis or gliding vertebra was first used by Killian in 1853. The condition itself had previously been mentioned by Herbineau in 1782, Rokitanski in 1839 and Belloc in 1849.[3]

volved vertebral segment, variable degrees of thinning of the subjacent disc, sclerosis of the superior surface of the slipped body, gross distortion of the neighboring ligaments and other soft tissues (including variable degrees of stretching or compression of the segmental spinal nerves). There is usually much new bone formation on both the first sacral and fifth lumbar bodies. The slipped body may even overlap the mid-sacrum.

In the intermediate stages (early and moderate) the changes are correspondingly less or more marked, depending in part on the amount of associated, coincidental trauma, the physiological status of the patient, and the presence or absence of complicating inflammatory disease.

The fifth lumbar body is sometimes abnormal in shape (shortened, markedly wedged, or hatched shaped). The foreshortening is usually on a congenital basis. The wedge shape is nearly always similar in origin and often accompanied by a horizontal type of sacrum. The hatchet shape may be congenital or acquired, the latter developing especially in cases of long-standing true slipping.

DIAGNOSIS

The diagnosis of minimal or early cases of spondylolisthesis is largely a roentgenological problem. The essential criteria for the establishment of a diagnosis of true slip are the roentgen demonstration of (*a*) unequivocal forward displacement of a vertebral body, in the presence of (*b*) a defect, or defects, in the interarticular portions of the neural arch of that segment.

The first requires a correctly positioned and exposed lateral roentgenogram of the lumbosacral spine, made sometimes in the erect as well as the horizontal position (since some slips are evident only in the erect position). The second requires oblique projections of the lumbosacral area made

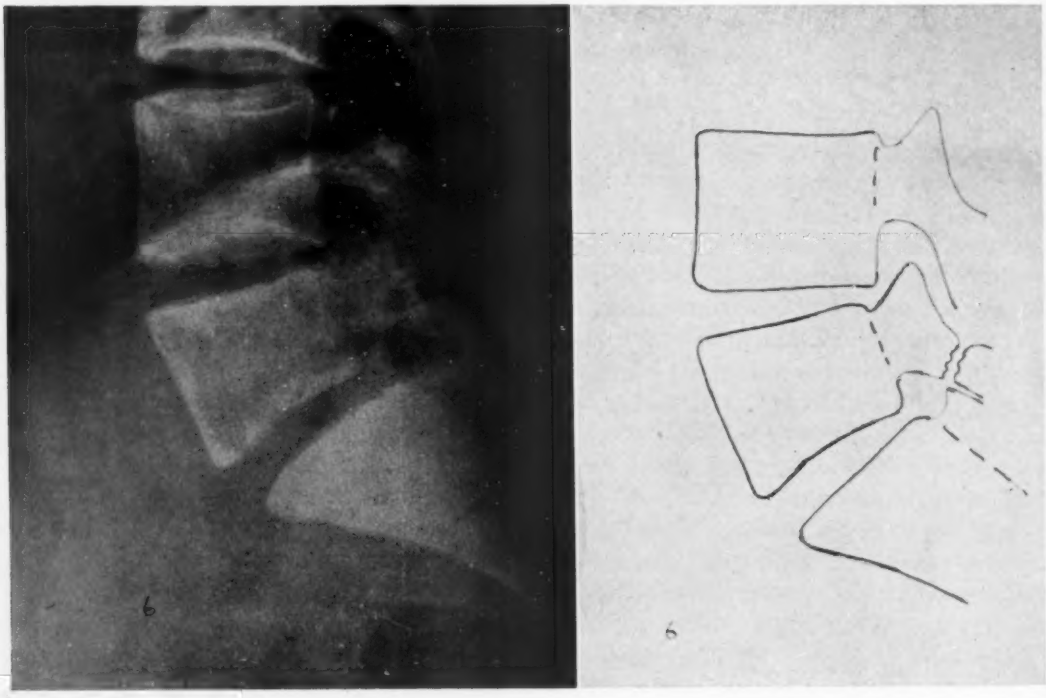

FIG. 6. Neural arch defects in the fifth lumbar, without slip. By former standards, relying on the plane of the posterior surface of the fifth lumbar, a grade 1 spondylolisthesis would be reported in a case of this type. Close inspection reveals that the fifth lumbar body is foreshortened, and that its anterior margin is *not* displaced.

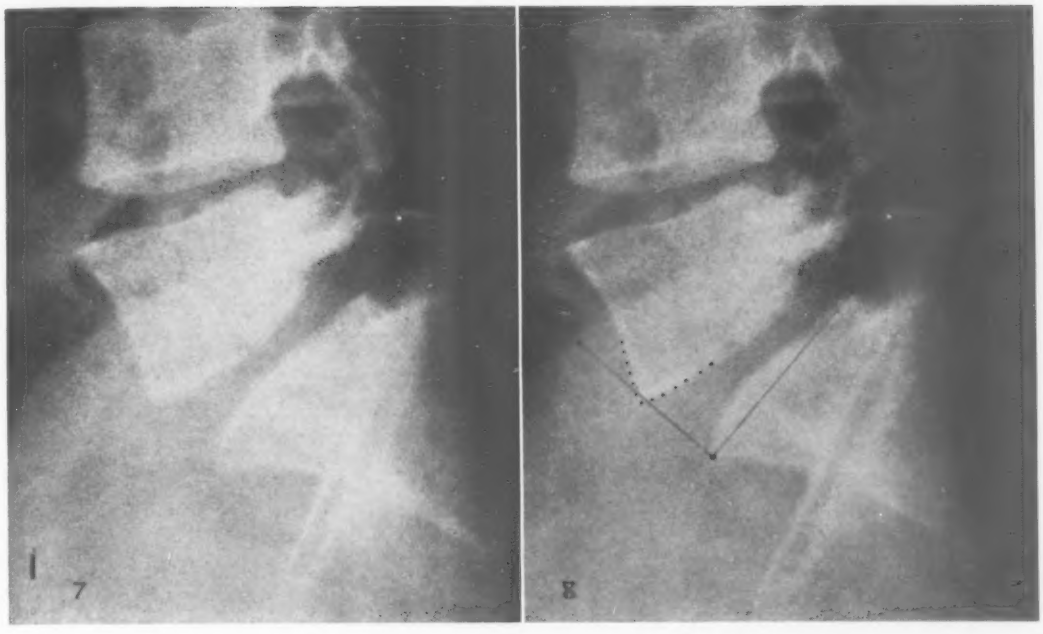

Fig. 7. Neural arch defects in the fifth lumbar, with slip. Spondylolisthesis, partial grade 1, slip about 4 mm.
Fig. 8. Same case as Figure 7, showing use of rectangular test line. In this case, the anterior inferior edge of the fifth lumbar body crosses the test line (instead of lying from 1 to 5 mm. behind it). This is a fairly reliable index of true slip, subject to the anatomical restrictions mentioned in the text.

with the patient at the optimum angle to show his particular defect, an angle found only by trial and error, but usually in the range of 35° to 50° with the horizontal. The defects may be visible in the anteroposterior views, but should always be confirmed by oblique projections, except in advanced cases.

In addition to the above criteria, the following findings are sometimes of value, especially in the more advanced cases, and may be seen in routine anteroposterior views: (*c*) overlapping of the shadows of the transverse processes of the involved segment on those of the subjacent one, (*d*) obscuration of the margins of the involved body; this body may be "invisible" in the anteroposterior view or may show as a crescentic shadow overlying the subjacent one (Brailsford's "bow" line), (*e*) apparently increased density of the fifth lumbar body, owing to the overlapping.

These latter findings will be enhanced in subjects with an acute lumbosacral angle. When the sacrum is of the "vertical" type its superior surface tends to be horizontal and give good support to the spine in the erect position; when the sacrum is of the "horizontal" or sharply angulated type (in reference to the lumbar spine), its upper surface naturally gives less support to the spine above, and more readily allows a slipping fifth lumbar body to glide forward. Conversely, in patients with a horizontal type of upper sacrum, the more easily will such a slip be detected in routine anteroposterior roentgenograms.

DISCUSSION

Upon what criteria can the detection of slight forward slipping of a fifth lumbar body be based? If the posterior edge of this body is forward in relation to the posterior margins of the first sacral body, but its anterior margin is not displaced, is there a true slip? We believe that there is *not*, for the following reasons: Examination of the roentgenograms of the lumbosacral spine of many hundred individuals with and without backache discloses the fact that a small

but significant percentage of persons have a foreshortened fifth lumbar body, and, apparently, relatively elongated pedicles. When no arch defects are present, this anatomic variation is usually overlooked, or at least not mentioned. However, when arch defects are present, the attention of the examining roentgenologist tends to be focused on the associated problem—slipping. He then notes the apparent displacement of the fifth body (as judged by its posterior margin), ignores the absence of displacement of its anterior margin, and reports "spondylolisthesis, grade 1."

Fig. 9. Neural arch defects, with slip (spondylolisthesis grade II). Note the overlapping of the shadows of the fifth lumbar transverse processes on those of the first sacral; the obscuration of the outlines of the fifth body; the apparent increased density of the fifth body, and the angulation and crowding of the laminae and spinous processes of the lower lumbar vertebrae—all indirect signs of slip in the anteroposterior projection.

Anterior Margin Displacement. What are the criteria for determining forward displacement of the anterior margin of a lumbar body? In the case of segments above the fifth, the problem is usually simple: one can usually employ the anterior margin of the subjacent lumbar body as a base line. However, in the case of the fifth lumbar body, a base line or norm is difficult to establish. After trial of various methods, we decided on the use of a line drawn perpendicular to the upper surface of the first sacral body, at its anterior superior margin. We found that in all normal individuals (that is, persons without spondylolisthesis, etc.) the anterior inferior margin of the fifth lumbar body lay from 1 to 8 mm. *behind* this line. In persons with fifth lumbar bodies of normal length and any definite degree of spondylolisthesis, the anterior inferior margin of the displaced body always touched or lay in front of this line.

On reviewing the literature, we find that this line was reported over twenty years ago by Ullmann[18] but has apparently not been generally used. Capener,[5] Brailsford,[3] and Mitchell[15] reported somewhat favorably on its use; Glorieux and Roederer,[8] Bowman and Goin[2] unfavorably. Its delineation requires *adequately exposed, true lateral* roentgenograms, centered over the lower lumbar spine and preferably at a distance of at least 36 inches. In a minority of cases the line may be difficult or impossible to establish because of one or more of the following reasons:

(1) The anterior superior margin of the first sacral segment may have a blunt, rounded profile.

(2) This margin may have an osteophyte on it. (Actually, this complication is unu-

Fig. 10. Lateral projection of same case as Figure 9, showing neural arch defects, molding of the inferior surface of the fifth lumbar, thinning of the disc, sclerosis of the adjacent body margins and rounding of the superior surface of the first sacral. The test line is never required in gross cases of this type.

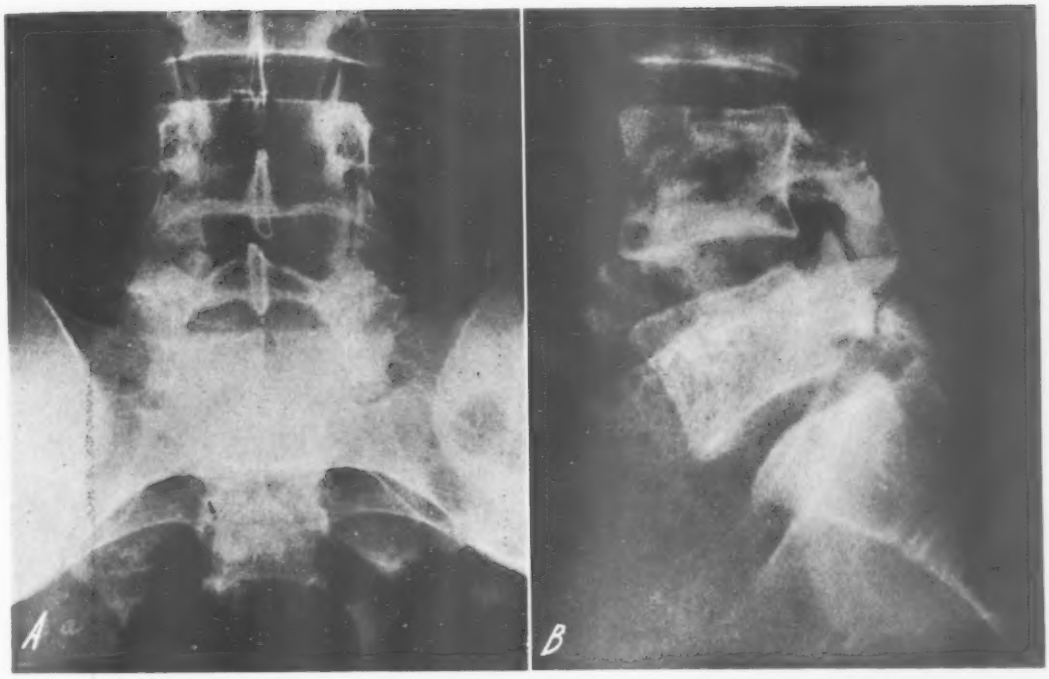

Fig. 11, *A* and *B*. Spondylolisthesis grade 1, partial, slip about 2 mm. This case is shown to illustrate the fact that many cases of slip with apparent unilateral arch defects can be shown to have bilateral defects if adequate study is made. The defect in the left side of the neural arch is visible in the anteroposterior view (*A*) but not that in the right (*B*).

sual in the minimal or early cases of olisthesis, which are the only ones in which the vertical test line assumes any importance. In patients with such degrees of slip that the first sacral segment shows new bone production, the question of definite diagnosis rarely arises.)

(3) The superior surface of the sacrum may be convex, concave or sinuous in profile, and the base line may be difficult to establish. In such cases one uses the anterior and posterior edges of the segment and draws a line between them. The perpendicular test line is then erected on the anterior end of this line.

(4) When the sacrum is of the extremely horizontal type, its superior surface is almost vertical, and the resultant test line may be deceptive. In such cases its use becomes of doubtful validity.

(5) A markedly wedge-shaped last lumbar disc (narrow posteriorly and wide anteriorly) may produce similar complications.

(6) Finally, a fifth lumbar body with unusually flared lower margins may, even in the absence of any arch defects, give a "positive" result in the presence of a vertical type of sacrum.

Despite the above complexities, the vertical test line may be established in the majority of correctly made lateral roentgenograms of the lumbosacral spine, and true ventral displacement of the fifth lumbar body may usually be diagnosed when the anterior inferior margin of the body with neural arch defects lies anterior to it.*

Posterior Margin Displacement. The posterior margin of the fifth lumbar body in most normal individuals bears a linear relationship to that of the first sacral. A smooth, continuous curved line will result from joining their respective upper and lower posterior edges. However, in a small

* Method. In actual practice, we mark with wax pencil the anterior and posterior margins of the upper surface of S1 and the lower anterior margin of L_5 on the lateral film. Then we use a transparent rectangular guide, with millimeter scale; a cleared 5×7 inch film makes a convenient test "ruler."

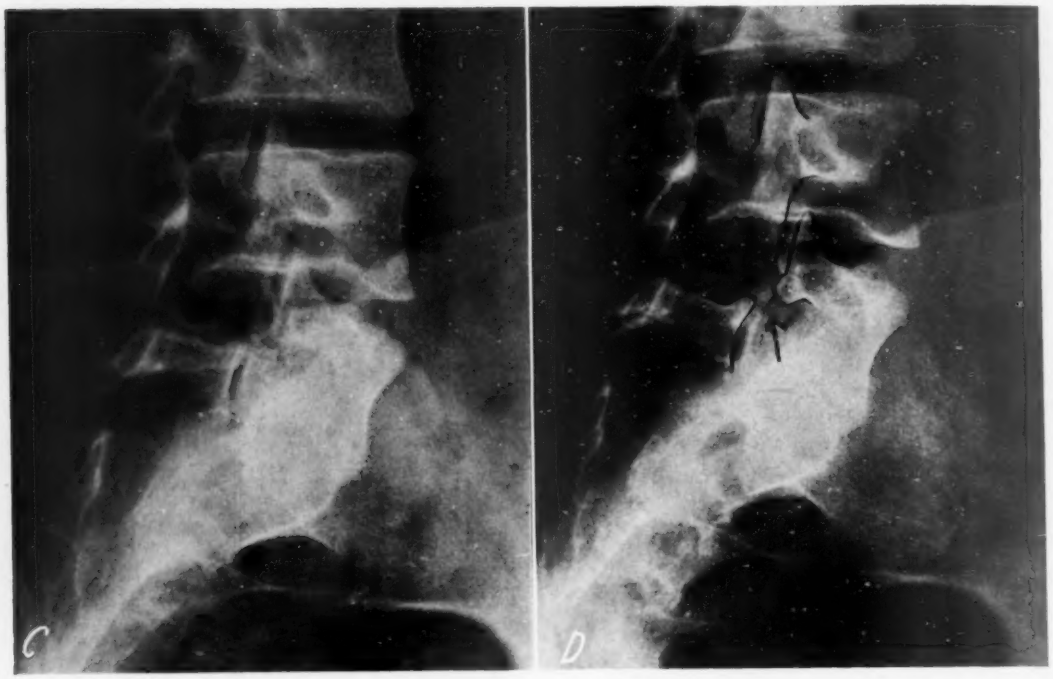

Fig. 11, *C* and *D*. Left posterior oblique views (about 40°) showing large gap in left neural arch of same case.

but definite percentage of individuals the fifth lumbar body will show variations in shape and size which render quite void the use of these landmarks to determine slip. Most of these individuals have a foreshortened fifth lumbar body. The body may be foreshortened generally or just in its caudal half. As a result, its posterior inferior margin will lie on a plane ventral to that of the first sacral, and the physician glancing casually at the roentgenogram will conclude that a grade 1 spondylolisthesis is present. The proof, in such cases, that slip is not actually present is obtained from the fact that the anterior edge of the body is not in front of the perpendicular test line.

Conversely, it is to be recognized that slip might be present (the anterior inferior edge of the fifth lumbar crossing the test line), but the posterior margin of this body appear to be in alignment with that of the first sacral. This could occur in very rare cases of platyspondyly of the last lumbar segment, or could apparently be present when new bone production results in formation of a spur or ridge on the posterior inferior margin of the body of the fifth lumbar body. We have seen examples of the latter, but not of the former.

The foreshortened fifth lumbar body is often associated with a wedge or hatchet shape in profile view. In long standing cases of olisthesis, it is quite common to see compression of the posterior and inferior surfaces of the fifth body, as a result of repeated gliding traumata. The associated bony changes (sclerosis, osteophyte production, etc.) will nearly always serve to distinguish this acquired hatchet shape from the true congenital type. The important element in the disturbed shape is the foreshortening of the caudal half of the body.

We studied the lumbosacral spine roentgenograms of 170 consecutive cases in an effort to establish data for measurement of this foreshortening, comparing the respective lengths of the last lumbar and the first sacral bodies. The subjects were mostly white males, between the ages of eighteen

and forty years, of average height and weight (that is, there were no grossly overweight individuals, and no skeletal freaks in the group). About 10 per cent of them were females. The following facts were found:

(a) The *length* of the fifth lumbar body: There were 61 cases in which the inferior margin of the fifth lumbar body was from 1 to 10 mm. shorter than that of the superior margin of the first sacral body. Counting only those cases in which the difference in length was 3 or more millimeters, there were 25. That is, approximately 15 per cent of the group showed notable and potentially significant *foreshortening* of the fifth lumbar body.

There were 36 cases in which the two margins were identical in length.

There were 73 cases in which the inferior margin of the fifth lumbar body was from 1 to 4 mm. longer than the first sacral. If we include only the cases with a difference of 3 or more millimeters, there were 23. That is 13 per cent of the group showed slight elongation of the fifth lumbar. None of this particular group showed any significant degree of platyspondyly.

(b) The *shape* of the fifth lumbar body: There were 146 cases with a normally "rectangular" fifth lumbar body, and 24 cases (14 per cent) with a more or less hatchet-shaped body. Actually, most fifth lumbar bodies that "look" rectangular in lateral projections are found by measurement to be slightly wedge shaped, i.e. the vertical dimensions of their posterior margins are from 2 to 8 mm. less than the vertical dimensions of their anterior margins, *but they are not caudally foreshortened.* It is this foreshortening (either caudal or general) that causes confusion in the diagnosis of slip, and that produces the appearance we term "hatchet shaped."

In an attempt to establish figures that might be of value in determining foreshortening, the sagittal lengths of the inferior margins of the fourth and fifth lum-

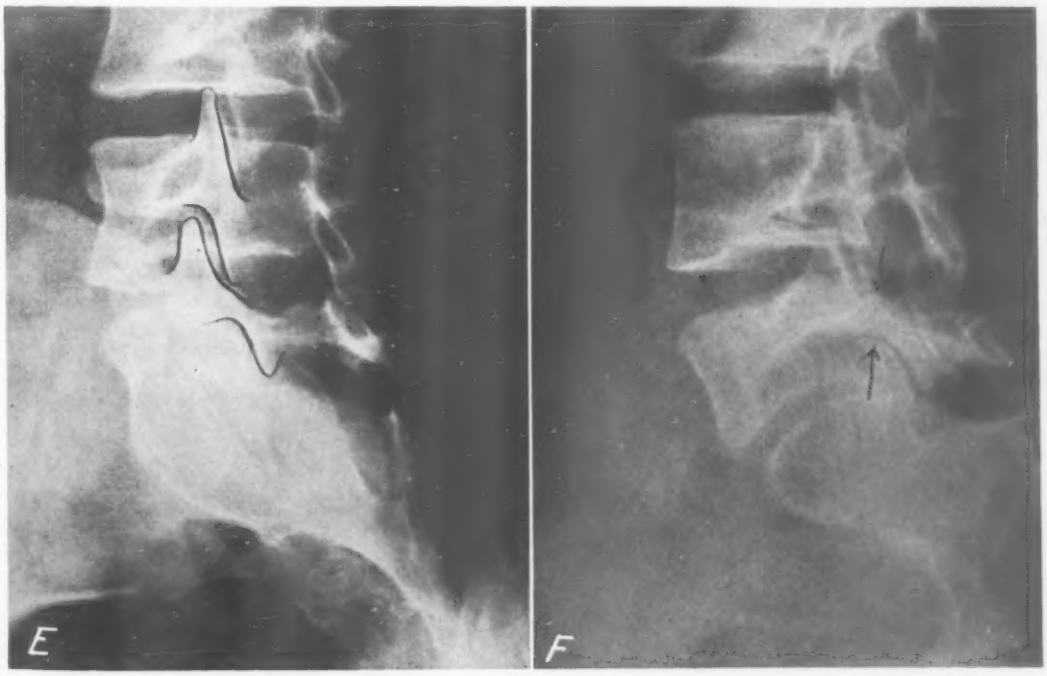

Fig. 11, *E* and *F*. Right posterior oblique views (*E* at about 40°, *F* at 60°). The fine cleft in the right side of the neural arch is only visible in the latter projection. Same case as preceding.

bar bodies and of the superior margins of the first sacral body were recorded in millimeters directly on lateral roentgenograms, made at 36 inch distance. In 3 cases, multiple lateral exposures were made, centering

Fig. 11, *G*. The fine cleft in the right side of the neural arch is slightly retouched. Same case as preceding.

at the mid-lumbar, the lower lumbar and finally the upper sacral planes. These variations in centering did not produce significant alterations in the recorded measurements. The figures obtained are given in Table I.

It is evident that when the fifth lumbar body has a conventional shape, it tends to be of the same length as the first sacral, but that when it has a hatchet shape, it tends to be on average 2.2 mm. shorter. It is noteworthy that this foreshortening is also evident on comparing the length of the fifth body with that of the fourth. Therefore, the presence of a hatchet-shaped body gives a visible clue to the presence of potentially significant foreshortening.

(c) The relative *position* of the fifth lumbar body: The question of true slip and pseudo slip was next analyzed. In the entire group of 170 cases, there were 20 with bilateral defects in the neural arch of the fifth lumbar (12 in the group with normal-shaped bodies, 8 in the group with hatchet-shaped bodies). Of these 20 with defects, only 8 showed spondylolisthesis according to our criteria (i.e. forward displacement of the fifth lumbar body as judged by the location of its *anterior* as well as its posterior margins). But, had we been guided by generally accepted procedures, and used the posterior margin of the fifth lumbar as the main criterion, *13* of them would have been classified as grade 1 olisthesis.

The relation of the perpendicular test line to the anterior inferior edge of the fifth lumbar body was as follows (all measurements in millimeters directly on 36 inch distance lateral roentgenograms (Table II).

The relationship of the posterior edge of the fifth lumbar to that of the first sacral body was also recorded directly on the roentgenograms in millimeters. The results shown in Table III were obtained.

Table I

Group	Length of Margins of	Average	Maximum	Minimum
Normal-shaped bodies (L5)	L4 inferior	45.6	58	36
	L5 inferior	44.2	55	35
	S1 superior	44.5	52	37
Hatchet-shaped bodies (L5)	L4 inferior	44.4	50	39
	L5 inferior	42.2	50	37
	S1 superior	44.4	52	37

In the foregoing discussion and, indeed, throughout most of this paper, the expression fifth lumbar vertebra is used to connote the last free lumbar segment. Other things being equal, similar remarks would apply to either the fourth or sixth lumbar segment, in cases with that number of segments, and in whom the problem of determining slip arose. It is for purposes of simplicity that the term "fifth lumbar" has been adhered to throughout.

Table II

Group	Perpendicular Test Line in Front of Anterior Inferior Margin of Fifth Lumbar		
	Average	Max.	Min.
In 150 cases without arch defects	3.6 mm.	8	1
In 12 cases with arch defects but no true slips	2.0 mm.	5	0
In 8 cases with arch defects, and true olisthesis	−3.0 mm.	−9	0

In cases with spondylolisthesis of a vertebral segment proximal to the last free lumbar segment (usually the third or fourth lumbar body, in patients with the normal number of lumbar segments), the problem of detecting slip is much easier, except when the subjacent disc is extremely wedge shaped and the superior horizontal surface of the subjacent body tilted downwards anteriorly to a marked extent. In the latter event a perpendicular test line may be of use. The apparent length and shape of the involved body should always be noted (since the third or fourth lumbar body may itself be hatchet shaped and foreshortened).

It is interesting and noteworthy that a foreshortened lumbar body, in the absence of olisthesis, is usually correctly aligned anteriorly; its posterior margin is almost invariably the one which is out of line, being ventral to those of its fellows.

Table III

Group	Relation of Posterior Surface of Fifth Lumbar to Posterior Edge of First Sacral
In 150 cases without arch defects	110 showed normal alignment 10 were anterior to S1 (1–3 mm.). That is, these cases had foreshortened bodies and would have been erroneously labeled slips if defects had been present (pseudospondylolisthesis) 30 were posterior to S1 (2–7 mm.). That is, these cases had slightly *elongated bodies* or anomalous facets were present. Some would call them "reverse spondylolisthesis" had arch defects existed
In 12 cases with defects, but no true slip	5 were anterior to S1 (2–3 mm.). The bodies were foreshortened; there was no visible displacement anteriorly (no true slip)
In 8 cases with spondylolisthesis (7 grade 1, 1 grade II)	8 were anterior to S1 (2–9 mm.)

Meschan* has recently reported an improved method of posterior margin mensuration using two lines: the first line is drawn from the posterior inferior margin of the body above the suspected segment of the posterior superior margin of the body below that segment; the second line joins the posterior superior and posterior inferior margins of the suspected segment. These two lines may form an angle or lie parallel with each other. Meschan believes that slip is present (*a*) when an angle is formed with the apex falling above the involved body (and not present when it falls below that body), and (*b*) when the lines are parallel but separated 4 or more millimeters. He classifies an angle of less than 10° as slight slip, 11°–20° as moderate and over 20° as severe. If erect lateral roentgenograms (made in neutral or hyperextended posture) reveal an increased angle he regards the lumbosacral angle as "unstable."

The reliability of these lines were checked by the author with the following results:

(1) In 7 cases of definite slip (mostly partial grade 1) the angle was positive in all; however, the classification as to degree of slip did not agree with conventional ones; in 3 cases of only *slight* slip (of about

* Meschan, I. Spondylolisthesis. Am. J. Roentgenol. & Rad. Therapy, 1945, *53*, 230–243.

2, 3 and 9 mm. respectively) the angle measured *moderate* slip (15°, 11° and 12°).

(2) In 6 cases of unilateral or bilateral arch defects without slip, the angle was positive in 1 and parallel lines were 5 mm. apart in 2; of these cases, 2 had foreshortened fifth lumbar bodies.

of 18 cases a negative "Meschan" test was found to be reliable in excluding slip in 7, but a positive test appeared to be somewhat unreliable in 11. Of these 11 "positives" only 7 had demonstrable slip by our standards; the test was therefore unreliable in about one-third of this small group of cases.

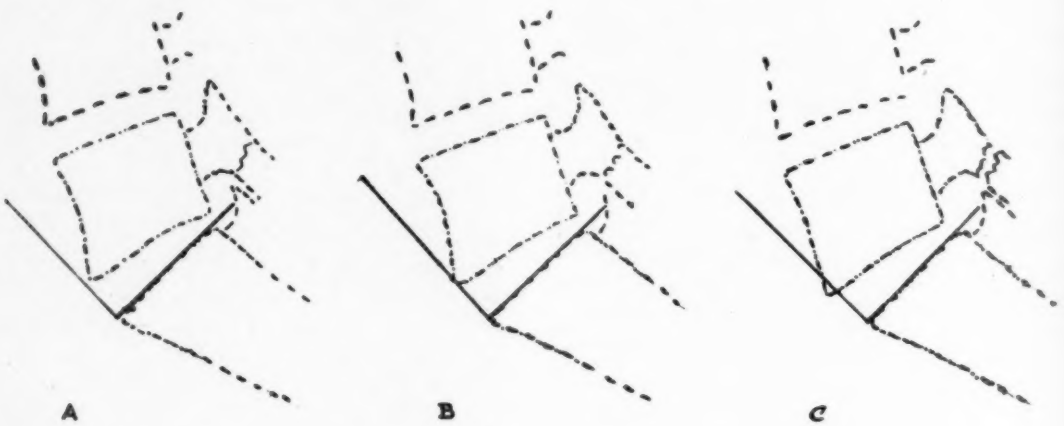

Fig. 12. Diagram to illustrate the use of the right-angle test line.

A, neural arch defects without slip. Note that the anterior margin of the fifth lumbar body lies about 3 mm. behind the test line.

B, neural arch defects without definite slip. The body of the fifth lumbar does touch the test line but its posterior edge is not significantly out of line and none of the other findings of olisthesis (see text) are present. Occasionally, cases of this type can be shown to slip slightly in the erect position.

C, spondylolisthesis, partial grade 1. The anterior margin of the body of the fifth lumbar crosses the test line.

(3) In 5 cases without defects, the angle was negative in 4 and positive in 1 (10°!); the latter was a case with an unusually greatly foreshortened fifth lumbar body.

In summary in a small but carefully studied series

General Data on Spondylolisthesis. The following additional statistical data bear on the general problem of spondylolisthesis and are noted here for the reader's information:

Table IV

VERTEBRAL SEGMENT INVOLVED IN SPONDYLOLISTHESIS*

Reference	Number of Cases	Percentage Incidence of Involvement Per Lumbar Segment						
		5†	4	3	2	1	5 and 4	3 and 2
Willis [19]	79	91	5	1	0	1	1	0
Burckhardt[4]	63	73	17	3	0	0	5	2
Garland[7]	38	74	18	0	2	0	3	0
Garland and Thomas (present paper)	8	87	13	0	0	0	0	0
Meyerding[14]	583	82	11	0.5	0.3	0	4.4	(double)**

* It is probable that some cases of "pre-" or pseudo-spondylolisthesis are included in Willis', Burckhardt's and Meyerding's figures. Our figures, in this table, list only cases of true slip as defined in this article.

† Or of last free lumbar segment.

** Exact location not specified.

Incidence of neural arch defects: Approximately 6 per cent of human skeletons (Willis[19]). Stewart[17] found them in 20 per cent of Eskimo skeletons. They are seen more commonly in persons with an increased number of presacral segments. We found them in 11.7 per cent of our series of 170 cases referred for lumbosacral spine examinations. Several were difficult to demonstrate and might have been overlooked if we had not been interested in the problem involved.

Anatomical location of the olisthetic segment: About 80 per cent involve the fifth lumbar vertebra; most of the remaining 20 per cent involve the fourth. Isolated cases have been reported involving the third, second and first lumbar bodies, respectively (Burckhardt, Willis, and others).[4,14,19] There are occasional cases of double displacement of two adjacent lumbar segments. Independent of the present series, we have seen one double slip of the fourth and fifth lumbar, and one isolated slip of the second lumbar.

Arch defects: In about 95 per cent of true olistheses the neural arch defects are *bilateral;* In the remainder the defects are or appear to be unilateral. The figures in the literature [6] are 75 per cent bilateral defects, 25 per cent unilateral; this has *not* been our experience. By making additional oblique projections at different angles we believe that most apparently unilateral cases will be found to be bilateral, at least, in cases of true slip.

Age factor: Until recent years some 50 per cent of cases were first noted in the third and fourth decades. Data from various military hospitals (including our own) suggest that this figure will soon be revised to read about 80 per cent of cases in those decades. The majority of the remainder occur in the ensuing decades. Kleinberg[11] reported in 1933 that there were no cases on record under the age of ten, but the next year he reported 1 case in an infant of seventeen months (grade II, discovered incidentally).[12] In 1940 Hitchcock[9] saw a case of neural arch defects without slip in a patient aged four.

Sex factor: Spondylolisthesis was once considered a predominantly female disorder. Recent literature gives a ratio of 76 per cent in males to 24 per cent in females. It is probable that the true ratio is closer to 50–50 (see also Hitchcock).[9]

Degree of slip:: According to the literature, some 30 per cent of cases show a grade 1 displacement (Meyerding).[13] Using our criteria we believe that the figure is closer to 80 per cent. Age and occupation will doubtless influence this element considerably. The older the patient, the greater the occupational or physiological strain (heavy work, multiple pregnancies), the higher the incidence of grade II and III slips. Grade IV slips are relatively rare, although several are on record.

SYMPTOMS

This highly controversial aspect of the subject will not be dealt with in the present paper, which is concerned essentially with the more accurate diagnosis of early cases. Suffice it to say that experienced roentgenologists and other physicians have reported extreme degrees of spondylolisthesis (grade IV) in persons without any symptoms referable to the spine or legs, while, on the other hand, some orthopedists have attributed "severe disabling symptoms to very slight degrees of slip" (grade 1).* It is our personal *impression*, based on private practice, previous general hospital and current naval hospital experience, that the vast majority of grade 1 lesions are *not* symptomatic.

SUMMARY

The roentgen diagnosis of spondylolisthesis should only be made when the vertebral body under suspicion can be shown to be actually displaced anteriorly in relation to the subjacent one.

The essence of olisthesis or slipping is

* Quoted by Bell, J. C., and Heublein, G. W., *Radiology*, 1944, *43*, 444.

that the whole vertebral body, and not just its posterior surface, is displaced anteriorly.

The confirmation of such displacement is aided, in early and minimal cases, by measuring the distance from the anterior inferior margin of the suspect segment to a line drawn perpendicular to the anterior margin of the subjacent uninvolved one (called the perpendicular test line). If the apparently displaced body does not touch or lie anterior to this line, it is not truly displaced, in the vast majority of instances. If the displaced body does cross it, a slip is virtually always present.

The reason why spondylolisthesis grade 1 is frequently reported, when it is not actually present, is that the body of the fifth lumbar (or involved segment) is *foreshortened*, so that while its posterior edge lies ventral to that of the subjacent segment, its anterior edge actually does not.

In view of the serious psychic and economic hazards sometimes ensuing from the use of the term spondylolisthesis, and implied (to inexperienced minds) by the term prespondylolisthesis, we believe neither diagnosis should be made casually.

If a true slip is present, it should be reported and the approximate degree of slip recorded in mm. (the term grade 1, popularly applied to slips involving up to one-fourth the sagittal diameter of the upper surface of the first sacral body, covers such a wide range that its usefulness is limited; if used, it should be qualified by words such as "partial" or "complete," and the approximate number of millimeters of slip noted).

If neural arch defects exist but no true slip is present, it would be correct to record the defects (e.g. "bilateral fissures in the neural arch of the fifth lumbar without visible displacement of the body") and omit the term prespondylolisthesis, especially since the case may never actually progress to slipping.

In a review of 170 consecutive lumbosacral spine roentgen examinations (made in reference to claimed backache or injury), it was found that 25 persons or 14.7 per cent had more or less *forshortened* last lumbar segments. In 15 of these no neural arch defects were present, but the posterior edge of the last lumbar body lay from 1 to 3 mm. ventral to the plane of that of the first sacral. In the other 9, arch defects were present, but in only 4 was the *anterior margin* of the fifth lumbar body ventral to the test line (that is, only 4 of the 9 showed true spondylolisthesis). There were an additional 4 cases of true slip with bodies of "normal" shape and length.

The remainder of the 170 cases, or 85.3 per cent, had last lumbar bodies that were either normal in shape and length or, in some instances, a little elongated, so that their posterior margins lay on a plane slightly behind that of the first sacral.

It may be stated that, in general, if the fifth lumbar body is normally "rectangular" in shape, and proportionate in size to its adjacent segments, there is a slip (olisthesis) *only* when its anterior margin reaches or passes the *perpendicular test line* drawn from the first sacral.

If the fifth lumbar body is foreshortened (especially caudally), and its shape in lateral projection is hatchet like, the relation of its posterior margin to that of the first sacral *cannot* be relied upon for the detection of slip. In extreme cases of foreshortening, its anterior margin might be equally unreliable, but such cases are very rare, since, as we have shown, the anterior margin of a foreshortened body is almost always correctly aligned anteriorly. Hence, strictly speaking, neither the anterior nor the posterior margin measurements are criteria in *all* cases, but, in the vast majority, the anterior margin measurements are the more reliable.

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LUMBOSACRAL ROENTGENOGRAMS OF ONE HUNDRED SOLDIERS

A CONTROL STUDY*

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INTRODUCTION

BACKACHE has been the subject of numerous roentgenographic studies. Injuries, faulty posture, congenital anomalies and disease have been described as causes of low back pain but there are many instances of backache in which no anatomic abnormality can be found. Conversely, roengenograms of the lumbosacral region made for reasons other than for backache have disclosed defects and variations which do not cause symptoms.[5,9,13,19] As the part of an investigation into the causes of backache among military personnel, 100 soldiers were examined as controls. The purpose of this paper is to present the abnormalities found in the roentgenograms of the lumbosacral region of this group.

MATERIAL

The subjects examined were all males between the ages of nineteen and thirty-nine years with an average age of 26.6 years. The age distribution is seen in Table I. With few exceptions these men had been subjected to strenuous military training and some had been in combat. Each was carefully interrogated with reference to back pain, recent or old, and any history of trauma to any part of the back. Only those who never had backache or suffered an injury to the back were included in this study. The roentgenograms which were obtained in each of the subjects consisted of: (1) routine views of the lower lumbar spine and sacrum in anteroposterior and lateral projections; (2) a roentgenogram made with the roentgen tube tilted cephalad at a 30 degree angle to show the sacrum, sacroiliac joints and the relationship of the transverse processes of the last lumbar segment to the lateral masses of the sacrum; (3) roentgenograms made in right and left semilateral projections with the subject rotated 30 to 45 degrees, for visualization of the laminae of the vertebral arches and the articular processes with their facets (Fig. 1). All of the roentgenograms were studied by each of us. In cases where there was any doubt as to the nature of an abnormality, stereoscopic roentgenograms and roentgenograms made in other projections were obtained for further study. Table II contains the details of the anatomical variations found in the roentgenograms of the entire group. Table III summarizes the principal abnormalities.

TABLE I

Age	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
Number	6	6	5	8	8	4	9	7	7	9	3	7	2	7	1	2	1	2	4	1	1

SPONDYLOLYSIS AND SPONDYLOLISTHESIS

Defects of the neural arch of the lower lumbar spine are not uncommon. The defect in the arch to which the term spondylolysis has been applied consists of an interruption of the bone between the inferior and superior articular processes, the pars interarticularis. This results in a division of the vertebra into two separate parts, the anterior portion consisting of the body with the pedicles, transverse processes and superior articular processes and the posterior portion which consists of the

* From Bruns General Hospital, Santa Fe, New Mexico.

TABLE II

Variations	No. of Spines
No variations	20
Generalized osteoporosis, slight	1
Congenital absence of inferior articular facets of L5. Spondylolisthesis of L5 upon S1, Grade II; L5 is wedge shaped and sacralized; failure of fusion of the arch of L5 in region of laminae; lumbosacral joint narrowed posteriorly; spina bifida of sacralized L5; acuity of lumbosacral angle increased	1
Spondylolysis of the arch of L5, bilateral; spondylolisthesis, Grade II; marked narrowing of lumbosacral joint; spina bifida of all sacral segments; degenerative changes and lipping about adjacent articular margins of L5 and S1	1
Spondylolysis of arch of L5, bilateral; spondylolisthesis of L5 upon S1, Grade I; asymmetrical facets; increased obliquity of superior surface of sacrum	1
Spondylolysis of arch of L5, bilateral; first degree forward, spondylolisthesis of L5 upon S1	2
Spondylolysis of L5, unilateral; Schmorl's nodule on inferior surface of L5; asymmetrical facets, lumbosacral articulation; spina bifida of S1	1
Schmorl's nodules on inferior surfaces of L3, L4 and L5; asymmetrical facets	1
Schmorl's nodule inferior surface of L5	2
Schmorl's nodule inferior articular surface of L3, L4 and L5	1
Unilateral (left) sacroiliac arthritis; asymmetrical facets, lumbosacral articulation	1
Degenerative arthritic changes about adjacent articular margins of L5 and S1	1
Transitional vertebra; spina bifida occulta of S1	1
Unilateral sacralization of L5 formation of false joint with degenerative changes	1
Increased acuity of lumbosacral angle	1
Schmorl's nodule on inferior surface of L3; spina bifida occulta of S1	1
Schmorl's nodule on inferior surface of L5; spina bifida occulta of S1	1
Narrowing of lumbosacral joint	4
Marked narrowing of lumbosacral joint and between bodies of L4 and L5; degenerative arthritic changes are present about articular margins of L4, L5 and S1	1
Moderate narrowing of lumbosacral joint and degenerative arthritic changes between adjacent articular margins of L5 and S1	1
Unilateral sacralization of fifth lumbar slight narrowing of lumbosacral joint; asymmetrical facets, lumbosacral articulation	1

TABLE II—*Continued*

Variations	No. of Spines
Transitional vertebra; asymmetrical facets; lumbosacral articulation; spina bifida occulta of S1	2
Ununited left inferior articular process of L4; asymmetrical facets; spina bifida occulta of S1, lumbosacral articulation	1
Spina bifida occulta of first sacral segment	12
Spina bifida of S2, S3, S4 and S5	1
Spina bifida occulta of L5	1
Spina bifida occulta of S1; slight narrowing of lumbosacral joint	2
Spina bifida occulta of S1; asymmetrical facets, lumbosacral articulation	7
Spina bifida occulta of S1; asymmetrical facets; lumbosacral articulation; Schmorl's nodule on inferior surface of L5	2
Failure of fusion of left inferior articular process of L2; spina bifida occulta of S1	1
Unilateral sacralization of L5	2
Transitional vertebrae	2
Transitional vertebra; asymmetrical facets, lumbosacral articulation	1
Asymmetrical facets between L5 and S1	21

TABLE III

Variations	No. of Spines
Spina bifida occulta	36
Narrowing of lumbosacral joint	11
Asymmetrical facets	39
Degenerative arthritis of lumbosacral joint	4
Sacroiliac arthritis	1
United epiphyseal centers	2
Transitional vertebrae	11
Increased acuity of lumbosacral angle	2
Spondylolysis	1
Spondylolisthesis	5
Schmorl's nodules	8
Generalized osteoporosis	1

laminae, spinous process and inferior articular processes. The etiology of this defect in the neural arch is still under dispute.[3,20,37] Spondylolisthesis is a better known term. It generally consists of a forward displacement of the fifth lumbar vertebra and spine upon the sacrum because of a congenital abnormality or injury. Less frequently the fourth lumbar segment is displaced and very occasionally

FIG. 1. Roentgenogram of the lumbosacral region made with subject rotated 45 degrees to show the vertebral arch and the articular processes with their facets. There is a wide defect in the arch in the region of the pars interarticularis.

spondylolisthesis is found at other levels. The underlying lesion preceding and resulting in spondylolisthesis is an interruption in the continuity of the neural arch in the region of the pars interarticularis (spondylolysis) or faulty development of the inferior articular processes permitting a forward displacement of the affected segment. Strong ligamentous structures maintain the relationship of the inferior articular processes of the last lumbar vertebra with the articular processes of the sacrum preventing the spine from slipping over the superior articular surface of the sacrum. A spondylolysis disrupts this bony anchorage.

Defects in the pars interarticularis were found in 6 per cent of the spines of the control group. In 1 of the spines the defect in the arch of the fifth lumbar segment was unilateral. This spine also had asymmetrical facets and there was a spina bifida occulta of the first sacral segment. Unilateral defects are not rare. Willis found this abnormality in 25 per cent of spines with spondylolysis. Four of the 6 spines with spondylolysis showed characteristic bilateral defects in the region of the pars articularis of the last lumbar vertebra and some degree of forward displacement upon the sacrum; 3 were of Grade I and 1 was of Grade II severity (Meyerding's classification).

One spine in which a Grade II spondylolisthesis was found presented the degenerative changes frequently seen in this condition (Fig. 2). The anterior margin of the first sacral segment was rounded off and there was a flaring collar-like ridge of excrescent bone formed around the articular margins of the first sacral segment and the overhanging portion of the adjacent articular margin of the fifth lumbar vertebra. These hypertrophic changes were

FIG. 2. Lateral view of the lumbosacral region showing a Grade II spondylolisthesis of the fifth lumbar segment upon the sacrum. The degenerative arthritic changes frequently seen in this condition are present.

limited to the articulation of the fifth lumbar with the sacrum and can be ascribed to local irritation of a chronic type resulting from mechanical strain. The absence of back pain even in the presence of advanced degenerative arthritis and severe grades of spondylolisthesis have been observed by others.[17,28]

Another spine which showed a Grade II spondylolisthesis had bilateral defects in the laminae. There was also a congenital absence of the inferior articular processes of the fifth lumbar vertebra mentioned by Goldthwait[14] and Müller.[28] The mechanism of forward slipping of the fifth lumbar segment in this spine differs from the others in this series and was attributed to the loss of the bony anchorage formed by the inferior articular processes. Normally these are in apposition with the superior articular processes of the sacrum and prevent the lumbar spine from gliding downward and forward on the oblique sacral articular surface.

Roentgenograms of the spines of large groups of men applying for industrial positions have been previously studied by Cushway and Maier,[9] and Breck, Hillsman and Basom.[5] All of these men were presumably asymptomatic. The incidence of abnormalities found in these groups varied considerably. In the series of 931 spines examined by Cushway and Maier only 3 instances (0.3 per cent) of spondylolisthesis were found. Breck and his associates found evidence of spondylolisthesis in 3 per cent of the 450 spines which they studied. Other groups studied roentgenographically showed a different incidence of this abnormality. George[13] found it in 3.5 per cent of 3,301 patients examined for symptoms referable to the lumbar spine. Another series of 500 spines reported by Kleinberg[23] showed an incidence of 2 per cent of spondylolisthesis and 2 per cent spondylolysis. Pheasant and Swenson[29] who examined the lumbosacral region of 171 cadavers roentgenographically, 42 of which were prepared, found evidence of spondylolysis in 1.1 per cent. Where large numbers of skeletons were examined the incidence of pars interarticularis defects coincided closely with the number found in the control series. Willis[35] found it in 5.19 per cent of 1,520 skeletons and Congdon[8] who studied the skeletons of 200 American aborigines in the Columbia river region encountered it in 5.0 per cent. Higher incidences of this abnormality are reported by Shore,[31] who found neural arch defects in 9.1 per cent of 56 Bantu South African native skeletons, and Stewart,[32] who reported an incidence of this variation in 39 per cent of 187 spines of Eskimos living north of the Yukon and 14.5 per cent in another series of spines of Eskimos on and south of the Yukon.

Fig. 3. Anteroposterior view of the lumbosacral region showing a transitional vertebra. The left transverse process impinges on the sacrum forming a false joint.

Sex has little, if any, influence on the incidence of neural arch defects in the region of the pars interarticularis. Some authors report a greater incidence of this abnormality in males while others find it more frequently in females.[4,28,38] Chandler[6] found that it occurred with the same frequency in both sexes.

ASYMMETRICAL FACETS

Asymmetrical facets at the lumbosacral articulations varying from slight to marked were found in 39 per cent of the spines in the control group. Slight variations were found in 27 spines; moderate asymmetry in 8 spines and in only 3 spines were the facets markedly asymmetrical. In addition to the variations observed in the obliquity of the articular facets, variations in their size and shape were found in individuals and in the vertebrae of the same individual. The stability of the lumbar spine, particularly the lumbosacral joint, is affected by the obliquity and direction of the articular facets. For example, facets which are situated in a transverse plane would prevent forward slipping and would allow sidewise displacement. Facets situated in a sagittal plane, on the other hand, would permit forward displacement. In practice, these facets are described as situated in oblique, sagittal or coronal planes but this is inaccurate. Examination of these articulations show that they are frequently curved, each facet corresponding to a segment of a cylinder. Horwitz and Smith[22] studied these articulations in cadavers and found that in some instances the superior facets of the lumbar vertebrae were sufficiently curved so that it was impossible for the roentgen rays to pass through the joint space. The shape of the facet as well as its obliquity recorded on the roentgenogram will therefore depend upon which component of the cylinder predominates. Other factors such as the inclination of the sacrum and the angle of projection of the roentgen rays must also be taken into consideration in the interpretation of variations of the articular processes and narrowing or obliteration of the interarticular joint spaces. No evidence of degenerative changes such as osteoarthritis, alteration in the joint space and articular surfaces of the facets and increased density of the adjacent articular surfaces were found in any of the spines studied in this series.

NARROWING OF THE LUMBOSACRAL JOINT SPACE

Some degree of narrowing of the lumbosacral vertebral joint space was found in 11 out of the 100 spines examined. This narrowing was marked in only 2 instances and with them there were degenerative arthritic changes of the adjacent articular margins of the vertebrae. Where there is an unusual amount of stress and strain, such as manifested in these cases, the narrowed lumbosacral joint space can be attributed to degenerative changes in the disc structures and cartilage. Herniation of the nucleus pulposus has been accepted as an important cause of narrowing of the disc space between the last lumbar and first sacral segment but would not explain the changes in many spines.[7,12] Disintegration of the annulus fibrosus incident to the wear and tear of life is another explanation of a narrowed disc space. Eight of the 11 spines showed only a slight narrowing posteriorly, estimated as about 2 mm. One of these was associated with a transitional vertebra, 4 with spina bifida occulta of the first sacral segment. Narrowed disc spaces are not infrequently found with a transitional vertebra and sometimes present themselves as thin sacral discs.[21]

Congenital narrowing of the joint space, according to Barr and Mixter,[2] is of rather frequent occurrence, but Vinke and White[33] were able to find only 3 instances in a group of roentgenograms of 300 children between the ages of five and fifteen in whom they were able to exclude other pathological conditions which would cause narrowing of the disc space. Williams[34] was able to find only 1 case of congenital narrowing in a like number of roentgenograms.

Prolapse of the nucleus pulposus into the adjacent vertebral body (Schmorl's node) was found in 8 spines. In 6 spines only one segment was affected. In the remaining 2 spines, three vertebrae showed the nodules. Ninety per cent of Schmorl's nodules occur in the lower lumbar spine.[25] No secondary changes in the bodies or facets were found with Schmorl's nodules in the control group.

ACUITY OF THE LUMBOSACRAL ANGLE

The acuity of the lumbosacral angle was found to be increased in 2 instances. In

1 of these spines there was a spondylolisthesis. Normally, the lumbosacral angle has an inclination of about 43 degrees but this is not constant. The weight-bearing axis of the spine normally passes anterior to the lumbosacral junction. Therefore, with an increase in the obliquity of the superior surface of the first sacral segment the shearing strain upon the lumbosacral joint becomes greater. This will in turn increase the strain against the posterior articulations which are subjected to added wear and tear. An increased incidence of osteoarthritis would be anticipated with acute sacral inclinations but this does not invariably follow.

OSTEOARTHRITIS

Osteoarthritis of the spine is usually the reaction to changes in the joint cartilages which have undergone degenerative changes attributable to age, trauma or other factors. Marginal bony proliferation of adjacent vertebral borders and osteophyte formation characteristic of osteoarthritis were found in 4 spines. One of these was associated with a Grade II spondylolisthesis; 2 were associated with definite narrowing of the joint space. Osteoarthritis is seen with increased frequency with advancing years. Beginning at about the thirty-fifth year of age, evidence of progressive degenerative changes can be found in the intervertebral joints.[36]

PERSISTENT OSSIFICATION CENTERS

Persistent ossification centers of the inferior articular process were found in 2 instances, once in the second and once in the fourth lumbar vertebrae. As a rule, these are bilateral and the adjacent surfaces of the ununited ossicle and articular process are smooth and sharply demarcated as compared with the ragged irregular margins of a fracture.[37]

TRANSITIONAL VERTEBRAE

Transitional type vertebrae were found in 11 spines. Four of these showed unilateral sacralization with long transverse processes. In 1 of the spines (Fig. 2) the transverse process was found to be impinging upon the upper surface of the sacrum producing a false joint. The adjacent surfaces of the impinging bones also showed degenerative changes and evidence of eburnation. Some writers believe that a transverse process which is impinging on the sacrum or ilia can cause clinical symptoms,[26] but in general the rôle of a long impinging transverse process as the cause of backache is open to question.[13,29,30] Spina bifida occulta of the first sacral segment was present in 7 of the 11 spines with transitional vertebrae.

SPINA BIFIDA OCCULTA

The incidence of spina bifida occulta has been reported by Dittrich[11] as 5 per cent of all spines examined roentgenographically. Cushway and Maier[9] found it in 17 per cent of 931 spines; Giles[16] found this anomaly in 23.9 per cent of 1,112 cases; and Breck and his associates[5] found it in 6 per cent of 450 spines. Meyerding[24] reported an incidence of 35 per cent of spina bifida occulta of the first sacral segment. The control group showed an incidence of 36 per cent. In 12 of the spines with this variation there were also asymmetrical facets. Other anatomical abnormalities were found in 14 per cent. Two of the spines with spondylolysis and spondylolisthesis in the control group showed this defect in the sacrum and in 1, all the sacral segments were thus affected. One of the spines showing a congenital absence of the inferior articular processes, with other anomalies, also had a spina bifida occulta of a sacralized fifth lumbar segment.

SUMMARY

The abnormalities in the lumbosacral region of the spines of one hundred asymptomatic soldiers have been studied and tabulated.

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OSTEOMYELITIS IN INFANTS

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OSTEOMYELITIS in infants shows anatomical and clinical differences from the disease in older children and adolescents. Prognosis as well as treatment is affected by these differences. These have been recognized by several observers in recent years who have placed the disease in a special category.

ETIOLOGY

The infection is blood borne as in most cases of osteomyelitis at other ages and its origin is thought to be the common respiratory diseases of infants, umbilical and skin infections. Frequently, however, no site of primary infection is found. The causative organism is the hemolytic streptococcus in the majority of cases while *Staphylococcus aureus* is the next most common cause. Green and Shannon[8] reported 76 cases of osteomyelitis in children under two years of age in which 48 (63 per cent) were due to the streptococcus; 22 (30 per cent) to the staphylococcus; 3 to the pneumococcus and 1 to the gonococcus. Paschlau[11] observed 31 cases under one year of age of which 14 were due to the staphylococcus, 5 to the streptococcus, 5 to a combination of streptococcus and staphylococcus and 7 to the pneumococcus. Others, Dillehunt,[5] Cass[1] and Stone,[14] though with fewer cases, reported a higher incidence of staphylococcus infection, viz., 7 were caused by the staphylococcus and 2 by the streptococcus. Dunham[6] noted a high incidence of streptococcus in septicemia of the newborn with a distribution as follows: streptococcus 15, staphylococcus 11, *B. coli* 10, pneumococcus 2 and pyocyaneus one.

The dominant rôle of the streptococcus in infants has been explained on the basis of a higher incidence of antecedent upper respiratory infection and relatively less natural immunity to the streptococcus in comparison with the staphylococcus.

PATHOLOGY

Certain anatomic factors contribute to the different nature of the disease in infants. The bone is of a more spongy texture, even in the so-called compact portion, the vascular spaces are larger and the cortex is thinner than in older children. These factors allow a freer communication between the marrow and the subperiosteal spaces.

The mode of infection in osteomyelitis through the capillaries in the juxta-epiphyseal region of the metaphysis is well known. As shown by Starr,[13] in adolescent osteomyelitis the infection passes more easily through the thin cortex into the subperiosteal space than into the shaft, with early and extensive periosteal elevation. Since the cortex in infants is thinner this is even more apt to occur and the medullary cavity of the diaphysis rarely becomes involved. The periosteum may rupture early with the formation of soft tissue abscesses. There is a minimum of bone destruction and sequestration occurs only in rare instances.

Daubenspeck[3] states that osteomyelitis in infants may occasionally arise primarily in the epiphysis and he bases his belief on the experimental work of Shioda.[12] India ink and bacteria were injected intravenously into young rabbits and these substances were found to reach the subchondral spaces of the epiphysis through "sinusoids" of the epiphyseal cartilage, independent of the perforating capillaries. These experiments could not be reproduced in older rabbits. The findings led Daubenspeck to believe that they could be correlated with those found clinically in infants and older children.

Pyarthrosis is a common complication. The infection may reach the joint in one of two ways: (1) It may spread from the

metaphysis through the adjoining epiphyseal cartilage. Since the cartilage is moderately resistant to infection, epiphysiolysis between the metaphysis and the epiphyseal cartilage may occur. More commonly, however, the infection is virulent enough to break through the cartilage into the epiphysis and through it into the joint. (2) In the joints in which the epiphyseal cartilage and a portion of the metaphysis lie within the joint capsule (proximal and distal humeri, proximal and distal femoral joints),[7] the infection need not traverse the epiphyseal cartilage to reach the joint, but only to break through the periosteum of the metaphysis. The cartilage of the joint is said to be relatively resistant to low grade infection; in virulent infection, however, cartilage as well as the epiphysis is destroyed with resultant deformities and arrest of growth. Serous, aseptic transudates are seen occasionally. These are secondary to the infection near the joint.

Metastatic involvement of other bones—usually of the long bones—is common. Metastatic soft tissue abscesses also occur. Such metastases develop primarily during the stage of septicemia.

Healing occurs rapidly in infants after surgical or spontaneous decompression. The small amount of necrotic bone is usually absorbed and persistent sequestra are uncommon. Formation of new bone is remarkably rapid. Green and Shannon[8] demonstrated formation of subperiosteal new bone as early as one week following the onset of infection.

CLINICAL COURSE AND TREATMENT

The usual clinical picture in the infant is quite different from that in other age groups. The onset is usually gradual and the common entrance complaint is swelling and loss of function of an extremity. Systemic manifestations are minimal, though there may be a low grade fever and moderate leukocytosis. These may be the only findings despite multiple sites of involvement. The differential diagnosis includes suppurative arthritis, cellulitis or soft tissue abscess, scurvy and congenital syphilis.

In some instances the picture is similar to that seen in older children where there is an acute onset with severe systemic manifestations. In these cases it seems that the bacteriemia, which is usually transient, persists and the subsequent course is that of a septicemia. Recovery in such cases is uncommon. In event of recovery from the septicemia the prognosis of the resultant osteomyelitic lesion is unaltered.

Following appropriate treatment in an uncomplicated case the course is benign, characterized chiefly by the rapid healing of wounds and sinus tracts. This usually occurs in from three to eight weeks, though local swelling may persist for a greater period of time and is probably accounted for by extensive formation of involucrum. There is an associated clinical recovery.

Treatment is general as well as local and adequate supportive measures are mandatory. Thus dehydration and anemia are corrected while the affected part is immobilized. Appropriate chemotherapy should be instituted. In some instances no more definitive treatment will be necessary as the osteomyelitis may heal completely. Any subperiosteal or soft tissue abscess must be adequately drained. Adequate immobilization (preferably by a plaster of paris cast) should be continued after the soft tissue abscesses have been drained.

Pyarthrosis is the most common complication and must be differentiated from aseptic serous effusion. For this reason, diagnostic aspiration of the joint is indicated. Epiphyseal separation is the next most common complication and results in residual deformities. Metastatic osseous and soft tissue abscesses are also frequent. Recurrence of the infection and development of chronic osteomyelitis is unusual.

ROENTGEN APPEARANCE

Since the disease runs a relatively benign course the first clinical evidence is usually soft tissue swelling. This may mean that the infection has broken through the

periosteum or into the joint. Roentgenograms in the early stages are rarely obtained. In our experience the earliest finding is an area of bone destruction in the metaphysis adjoining the epiphyseal line. A similar area may be seen in the epiphysis. The periosteum of the diaphysis is elevated. As a result of the effusion the joint space may be widened. Depending on the age of the infant and the affected joint, the epiphysis may not be ossified and its involvement, therefore, cannot be ascertained. On the other hand, the epiphysis may be decalcified or destroyed and only subsequent roentgenograms will show its viability. Partial or complete epiphyseal separation indicates infection of the epiphyseal cartilage.

Healing is evidenced by rapid subperiosteal formation of new bone and by a more discrete limitation of the bony defects and this is followed by restoration of the bony trabeculae. Sequestra are seen rarely; if present, they usually become absorbed. Depending on the extent of epiphyseal destruction there may or may not be restoration of the normal growth.

The course of the disease can be easily followed in the roentgenograms. Complete healing may occur as early as two months with minimal deformities visible for several months. There may be delay in the epiphyseal growth or failure of epiphyseal development with resulting deformities. Sclerosis and other signs of chronic osteomyelitis are uncommon.

There is a great variation in the mortality rate reported in the literature. An example of a high mortality rate is the series reported by Green and Shannon;[8] 21 per cent of the infants under two years and 44 per cent of those under six months died. Paschlau's[11] experience was similar. He reports a mortality rate of 38 per cent in 42 cases under one year of age. Cass,[1] Dillehunt,[5] and Stone[14] reported an unusually low death rate, probably due to absence of septicemia. In cases with persistent septicemia the comparative prognosis is poor. Thus in those cases in which Green and Shannon report a positive blood culture the mortality rate was 60 per cent for streptococcus infections and 66 per cent for staphylococcus infections. In infants who survive the septicemia the prognosis of the local lesion is excellent, compared to osteomyelitis in the older age groups.

Because of the unusual number of cases of osteomyelitis in infants in the last year, we would like to report in detail all of the cases which we have seen.

CASE REPORTS

Case 1. J. M., male (44-10915), aged four weeks, admitted October 27, 1944. Delivery was breech with forceps. On October 1, 1944, numerous small cutaneous pustules were noted. These were opened and treated with sulfathiazole ointment. One week prior to admission, swelling over the right shoulder appeared and three days later similar swellings were seen in the region of the left shoulder, left knee and left ankle. The right shoulder was drained prior to entry. Staphylococci were cultured from the pus.

On admission the baby was undernourished. There was an erythematous eruption over the entire body and swelling over the left shoulder. Both knee joints and the left ankle joint contained increased fluid. Thighs and legs were in flexion and extension provoked pain.

The temperature was 100.8° F., hemoglobin 9 grams and white blood cell count 12,000.

Roentgenograms revealed areas of destruction in the proximal metaphyses of both humeri as well as periosteal elevation (Fig. 1, *A* and *B*). The epiphyseal center on the right was separated. Other areas of destruction were seen in the distal metaphysis and epiphysis of the right femur (Fig. 3*A*), as well as in the upper medial end of the left tibia (Fig. 4*A*). The periosteum was elevated in all instances.

Treatment consisted of two blood transfusions and intramuscular penicillin; 15,000 units were given every three hours for a total of 4,200,000 units. Hospitalization lasted one month during which time the general health of the baby improved markedly.

Progress roentgenograms on November 7, 1944, revealed apparent increase in the bone destruction but roentgenograms taken on November 28, 1944, demonstrated improvement in the appearance of all lesions (Fig. 3*B*). On

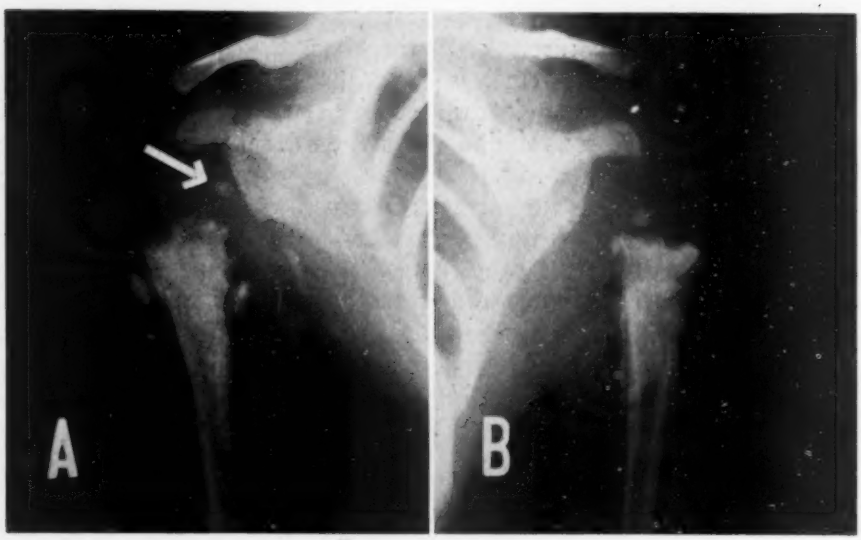

Fig. 1. Case I. *A*, November 1, 1944. Destruction of the metaphysis of the right humerus. There are several fragments of necrotic bone. Arrow points to the separated proximal epiphysis, *B*, November 1, 1944. Left humerus: Destruction is less marked. Mild periosteal elevation. Epiphysis shows normal relationship with the metaphysis.

re-examination on January 8, 1945, the lesions appeared well defined on the roentgenograms and there was evidence of healing (Fig. 4*B*). On March 8, 1945, the child appeared clinically well. There was no limitation of motion in any of the involved extremities and roentgenograms showed complete healing (Fig. 2, 3 and 4). The epiphyseal centers in both humeri were not visualized.

Comment. The multiple involvement was secondary to the cutaneous staphylococcus infection. The destruction in both shoulder regions with epiphysiolysis on the right occurred early and will probably result in permanent deformities. The rapid absorption of sequestra is well demonstrated. It would seem that penicillin had a beneficial influence on the course of the disease.

Case II. M. M., female (44-9964), aged two months, admitted September 16, 1944. The infant was breast fed for twelve days until the mother developed a breast abscess. At the age of four weeks the patient developed a temperature of 103°F. and a small area of erythema and

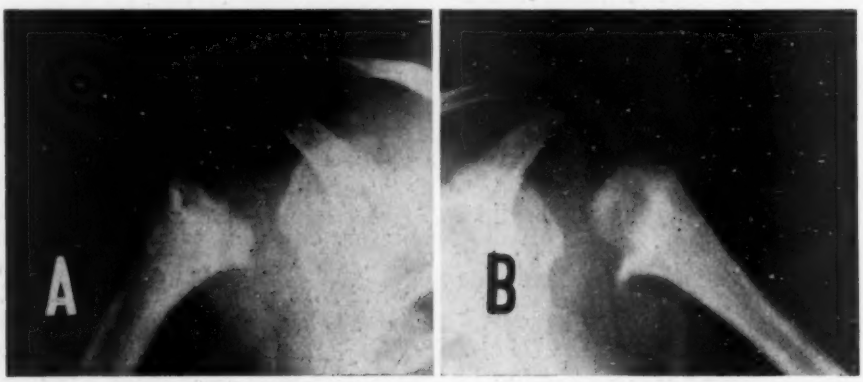

Fig. 2. Case I. *A*, March 12, 1945. Right humerus: The slight irregularity of the metaphyseal outline suggests incomplete healing. The epiphysis has been destroyed. *B*, March 12, 1945. Left humerus: Residual deformity of metaphysis after infection has subsided. Epiphysis has either been destroyed or decalcified.

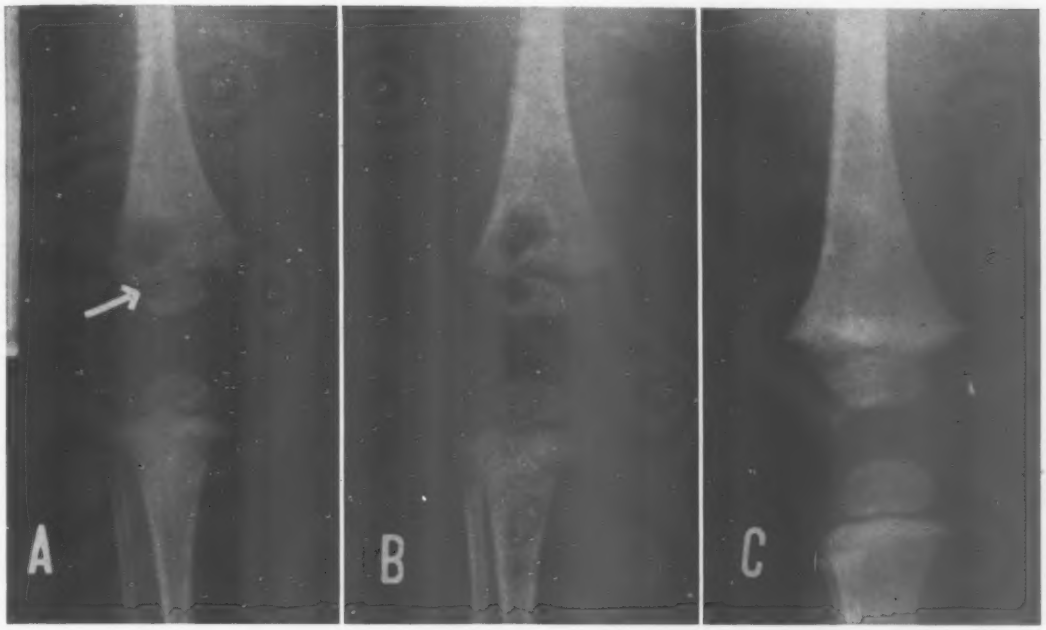

Fig. 3. Case 1. *A*, November 7, 1944. Right femur: Circular areas of destruction in the distal metaphysis. Defect in the cortex as well as a rarefied area in the epiphysis (arrow) are well seen. *B*, November 28, 1944. The defects show beginning reossification. Mild periosteal elevation along the lateral femoral aspect. *C*, March 12, 1945. Complete healing in the metaphysis and epiphysis.

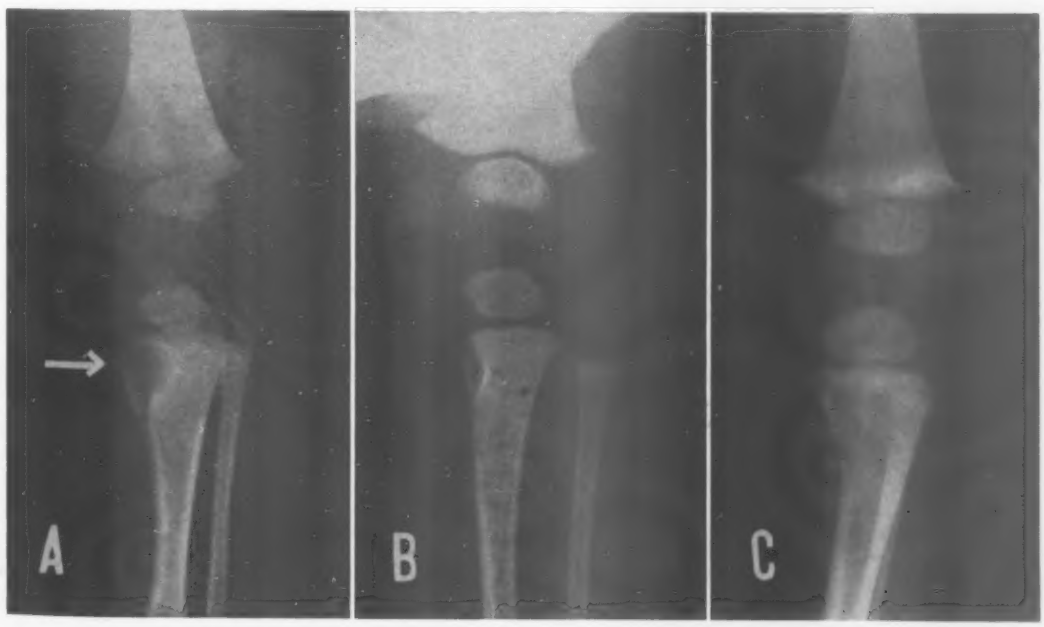

Fig. 4. Case 1. *A*, November 7, 1944. Left tibia: Arrow points to break in the cortex from the osteomyelitic abscess in the metaphysis. Slight periosteal elevation. *B*, January 8, 1945. The defect is beginning to fill in with new bone. *C*, March 12, 1945. Complete healing.

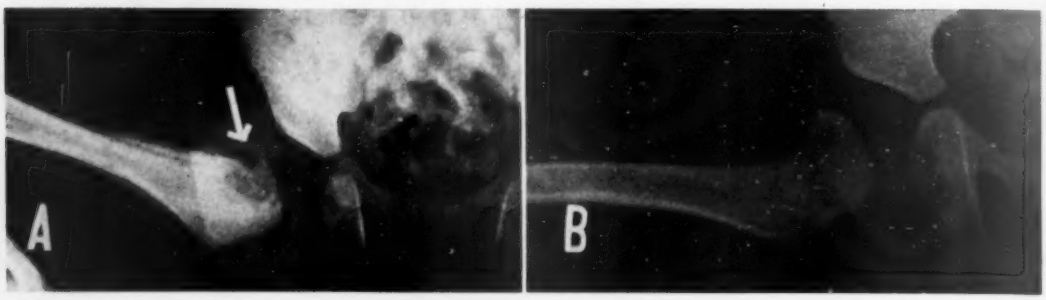

Fig. 5. Case II. *A*, September 16, 1944. Area of destruction in the metaphysis. Arrow points to break in the cortex. Some periosteal elevation is present. *B*, April 3, 1945. Complete healing. Normal development of the femur.

swelling over the dorsum of the left fourth finger. Five days later this was incised and pus obtained. Later swelling and tenderness in the region of the right hip was noted. Five hundred thousand units of penicillin were given during the ensuing three weeks. Roentgenograms on September 1, 1944, taken in another hospital, revealed effusion into the right hip joint and roentgenogram on September 13, 1944, showed destruction of the head of the femur.

On admission the infant appeared chronically ill. There was swelling in the region of the left fourth finger. Movement of the right thigh was painful.

Temperature was 99.4° F., hemoglobin 10.8 grams and white blood cell count 24,000.

Roentgenograms revealed an irregular area of bone destruction in the proximal right femoral metaphysis and mild periosteal elevation (Fig. 5*A*). There was marked destruction in the proximal phalanx of the left fourth finger and several sequestra were seen (Fig. 6*A*).

Treatment consisted of application of a single hip spica plaster of paris cast and 10,000 units of penicillin every three hours for a total of 400 000 units. The infant remained afebrile and improved during her hospital stay. Drainage from the hand gradually subsided. October 10, 1944, a sequestrum was removed from the left fourth finger.

On April 3, 1945, there was complete healing of the femoral lesion without limitation of

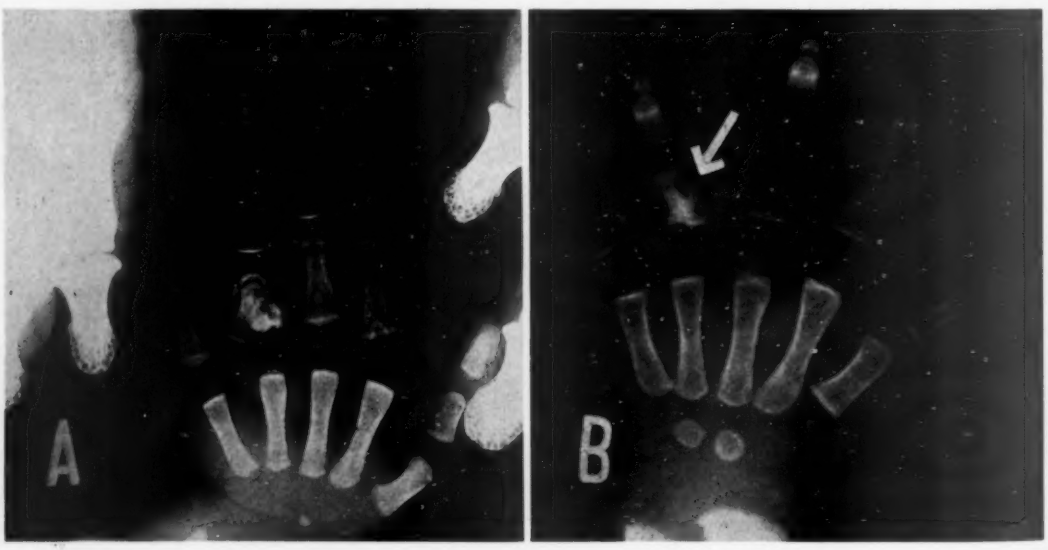

Fig. 6. Case II. *A*, September 16, 1944. Extensive destruction of the proximal phalanx of the fourth finger. Several sequestra are seen. *B*, April 3, 1945. Arrow points to a small cavity containing a minute sequestrum. The outline of the phalanx is smooth.

motion (Fig. 5*B*). The left fourth finger revealed a small abscess cavity with a minute sequestrum (Fig. 6*B*).

Comment. It is interesting to consider the possible relationship between the mother's breast abscess and the patient's infection. The infection in the upper extremity was farther advanced than in the lower extremity. Penicillin seemed helpful in producing the satisfactory outcome. This is the only case in which a sequestrectomy was performed and in which there is a persisting sequestrum.

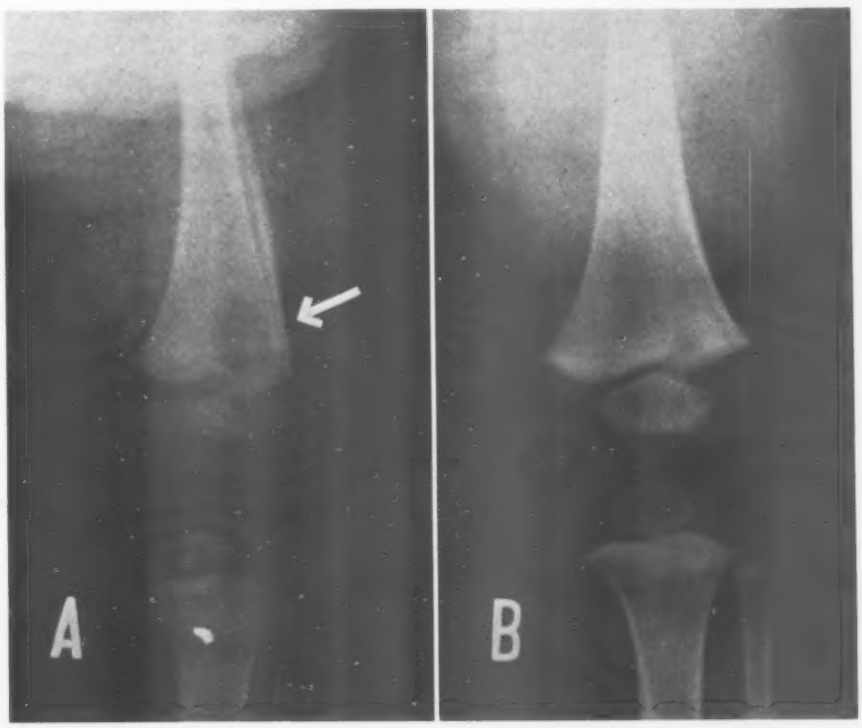

Fig. 7. Case III. *A*, August 11, 1944. Circular area of destruction in the lower femoral metaphysis. Moderate amount of periosteal elevation. *B*, March 26, 1945. Complete healing and normal growth of bone.

Case III. J. E., male (44-6368), aged five weeks, admitted August 2, 1944. Three days before admission the parents noticed swelling of the left knee. The temperature was normal but the infant was irritable. Previous medical history was not significant.

On admission examination was negative except for swelling of the left knee.

Temperature was 99° F., hemoglobin 12 grams and the white blood cell count 11,200. Roentgenograms revealed a circular area of destruction in the lower femoral metaphysis and periosteal elevation (Fig. 7*A*).

Treatment consisted of aspiration of the knee joint. A cloudy fluid was obtained which was negative on culture. Five thousand units of penicillin were injected into the knee joint and the procedure was repeated on two consecutive days. On August 11, 1944, the abscess in the left femur was drained. The knee joint was opened simultaneously and about 30 cc. of thick, creamy pus was liberated. Following this a single hip spica plaster of paris cast was applied. Intramuscular penicillin, 10,000 units every four hours, was begun on August 11, 1944, and continued until August 17 for a total of 600,000 units.

The cast was removed on October 20, 1944, at which time the wound had healed and full range of motion was present. The child was clinically well.

At the last examination on March 26, 1945, the roentgenograms showed complete healing of the lesion and there was no impairment of motion of the knee joint (Fig. 7*B*).

Comment. This infant had the shortest duration of symptoms of any of the cases seen by us. Penicillin given intramuscularly and into the knee joint probably attenuated the virulence of the infection. In spite of the extensive pyarthrosis—as proved at operation—there was no apparent residual impairment in the function of the joint.

Case iv. C. W., male (44-6176), aged three and one-half weeks, admitted June 28, 1944. Delivery was normal. Swelling of the right thigh was noted on the thirteenth day. This appeared painful on palpation and movement and the infant kept the leg flexed. Hot packs were applied until an area of fluctuation appeared over the lateral aspect of the lower right femur. Three days before admission this area was incised and drained.

On admission, examination was normal save for a small draining sinus in the region of the right knee. The thigh was swollen and indurated and the leg was held in flexion.

Temperature was 99.5° F., hemoglobin 11 grams and the while blood cell count 20,400.

Roentgenograms showed an area of destruction in the distal femoral metaphysis with periosteal elevation. The distal femoral epiphysis appeared normal (Fig. 8*A*).

Treatment consisted of intramuscular penicillin. Ten thousand units were given every four hours for a total of 600,000 units. On July 11, 1944, the soft tissue abscess in the region of the external femoral condyle was adequately drained. A chronic abscess cavity was found which communicated with the knee joint. The perforation into the joint was enlarged and about 10 cc. of thick, yellow pus was liberated, which was negative on culture. Vaseline gauze was loosely packed into the defect and a single hip spica plaster of paris cast and applied. The temperature remained normal and the general condition was good. When the cast was removed on August 16, 1944, the wound appeared to be healing (Fig. 8*B*). There was full range of motion in the knee joint.

At the last examination on January 12, 1945, roentgenograms revealed progressive healing of the defect. Only a minimal deformity in the metaphysis was present (Fig. 8*C*). The bone growth was normal and there was no limitation of motion.

Comment. Course and treatment are similar to Case iii. Of interest is the un-

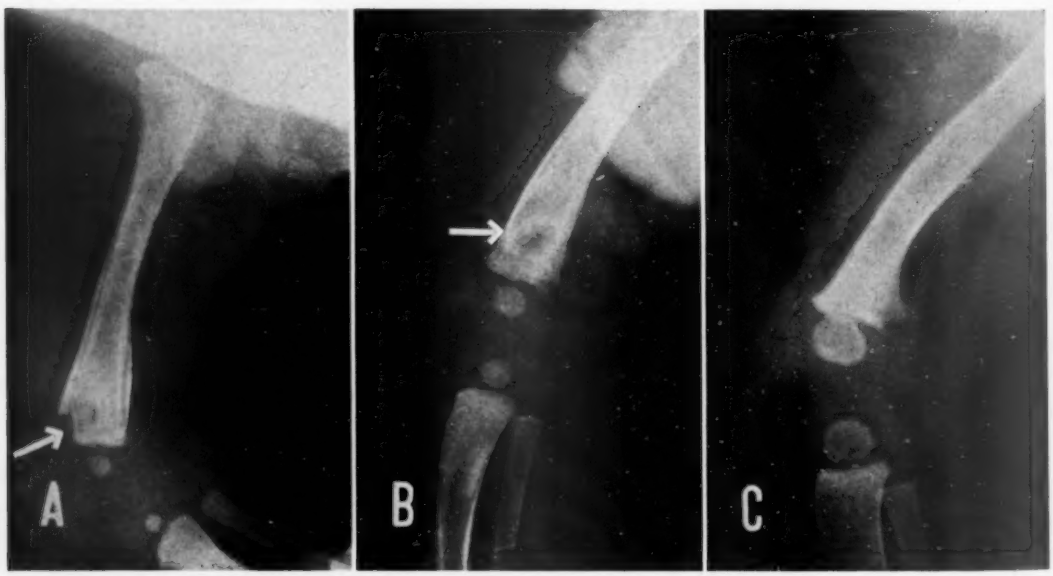

Fig. 8. Case iv. *A*, July 10, 1944. Area of destruction in the lower femoral metaphysis. Arrow points to break in cortex. Moderate amount of periosteal elevation. *B*, August 16, 1944. Healing progresses, while the femur grows normally. *C*, January 12, 1945. Only a mild deformity remains in the posterior aspect of the metaphysis.

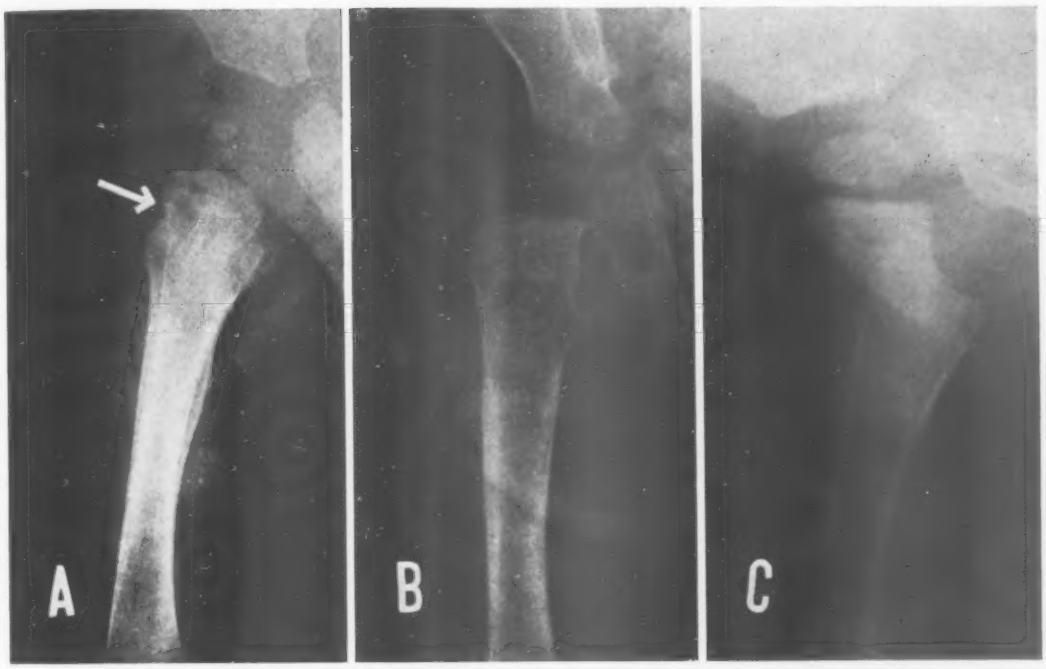

Fig. 9. Case v. *A*, June 12, 1941. Several areas of destruction in the metaphysis. Arrow points to break in the cortex. Moderate amount of periosteal elevation. *B*, August 11, 1941. The infection appears healed. *C*, April 7, 1943. Normal bone growth without residual deformity.

disturbed enchondral growth of bone in the presence of the metaphyseal abscess and involvement of the epiphysis—as demonstrated at the time of operation.

Case v. L. O., male (41-6896), aged five months, admitted June 12, 1941. Previous medical history was not significant. Swelling in the right hip region was noted at the age of two months. There was an associated febrile reaction. After immobilization for three weeks the hip region was incised and drained. Culture revealed pneumococci. The leg was placed in skin traction.

Examination on admission revealed a normally developed infant. The right thigh was in 20° flexion. Movement in the hip joint was free but painful. There was a small amount of purulent drainage from the wound.

Temperature was 99.6° F., hemoglobin 13.5 grams and the white blood cell count 17,500.

Roentgenograms revealed several well defined areas of destruction in the proximal femoral metaphysis as well as mild periosteal elevation. The capital epiphysis appeared normal (Fig. 9*A*).

Treatment consisted of immobilization in a one and a half hip spica plaster of paris cast for three months at which time the wound had healed and the child was clinically well.

Progress roentgenograms showed healing of the lesion (Fig. 9*B*) and the last taken on April 7, 1943, showed normal development of the right femur (Fig. 9*C*). Examination at that time revealed no limitation of motion.

Comment. The culture of pneumococci suggests an upper respiratory tract infection for the port of entry. The infection was subsiding when we saw this infant. Adequate treatment had been given early and no deformities resulted.

Case vi. L. M., female (41-11698), aged six and one-half months, admitted March 22, 1942. The child was adopted at the age of three and one-half months and was in good health until the age of four and one-half months when swelling over the right ankle was noted. The area was painful and tender. Temperature was 101° F. and a roentgenogram was said to be negative. Sulfathiazole was administered with

relief of symptoms. At six months the symptoms recurred and were not influenced by sulfathiazole.

On admission the child was normally developed. There was moderate swelling of the entire right thigh and leg with induration over the right ankle. Movement of the leg was painful.

Temperature was 100.2° F., hemoglobin 9.5 grams and the white blood cell count 13,800. the entire right femur and an area of destruction was seen in the proximal femoral metaphysis (Fig. 10*C*). The capital epiphysis appeared normal. The white blood cell count at that time was 16,200. Aspiration of the hip joint yielded no pus. Immobilization was continued. Progress roentgen studies revealed gradual healing of the tibial and femoral lesions. The last roentgenogram on November 10, 1944, showed complete healing (Fig. 11). Examina-

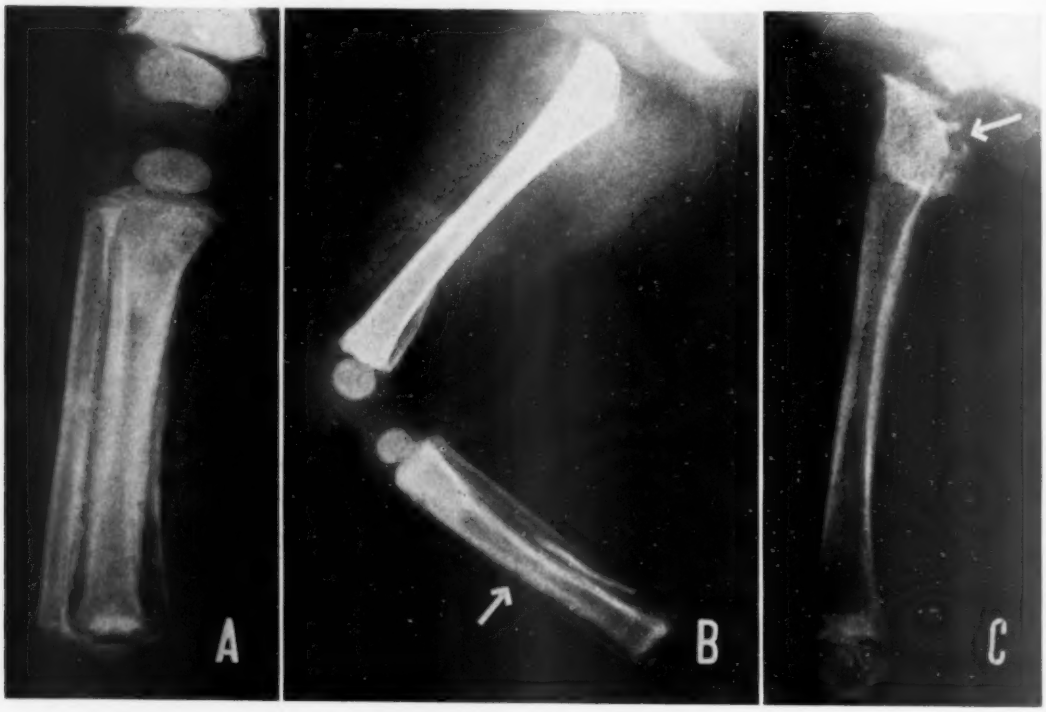

Fig. 10. Case VI. *A*, March 23, 1941. Extensive periosteal elevation of the tibia. No definite metaphyseal focus is seen, but there is some irregularity in the distal tibial metaphysis. *B*, March 23, 1941. Arrow points to infraction in the subperiosteal new bone and tibia. Note the periosteal elevation in the lower femur and the normal appearance of the proximal femoral region. *C*, May 12, 1942. There is now destruction in the proximal femoral metaphysis (arrow) and further extension of the periosteal elevation.

Roentgenograms revealed extensive periosteal elevation involving the entire right tibia and lower portion of the right femur. Infraction through the new bone and old cortex was seen in the anterior aspect of the tibia. The distal tibial metaphysis had a moth-eaten appearance (Fig. 10, *A* and *B*).

Treatment consisted of immobilization in a hip spica plaster of paris cast. A progress roentgenogram on May 11, 1942, revealed improvement in the appearance of the tibia. There was, however, periosteal elevation involving tion at that time showed equal development of both lower extremities and free movement of all joints.

Comment. The extensive periosteal reaction most marked in the distal tibial region was not observed in any of the other cases. It is similar to a case reported by Grevillius.[9] This case demonstrated the remarkable ability of the infant's skeletal system to combat infection and return to an essentially normal architectual structure.

Case vii. C. S., male (40-9254), aged seven months, admitted July 14, 1940. Umbilical infection developed after birth with purulent discharge lasting for eight weeks. At the age of three weeks the infant was said to have had pneumonia. Swelling in the left shoulder region was noted at the age of six weeks. This was drained one week following onset with liberation of about 4 cc. of pus. Drainage subsided after several days with healing of the wound.

On admission the temperature was 100.4° F., and the infant was normally developed. The left arm was held in adduction. Abduction and internal rotation were limited and painful. There was no soft tissue swelling.

Roentgenograms of the left shoulder revealed absence of the epiphysis and destruction in the metaphysis with a sequestrum (Fig. 12*A*).

Treatment consisted of immobilization in abduction. Roentgenograms showed progressive healing with persisting deformity of the proximal end of the humerus. He was well until March, 1943, when he was readmitted with a soft tissue abscess in the posterior aspect of the upper arm. The systemic reaction was minimal. The abscess was drained and culture revealed a non-hemolytic streptococcus. Roentgenograms showed no change over those taken previously. On his last visit on February 4, 1944, there was limitation of motion with a 30° abduction, good internal rotation but no external rotation. Roentgenograms showed absorption of the sequestrum and some sclerosis of the shaft. Two epiphyseal centers of the proximal humerus were present (Fig. 12*B*).

Comment. The focus of the infection could have been the omphalitis but the upper respiratory infection was a more likely cause. The sequestrum was absorbed grad-

Fig. 11. Case vi. November 10, 1944. Complete healing of the lesions in the right lower extremity. Normal bone development.

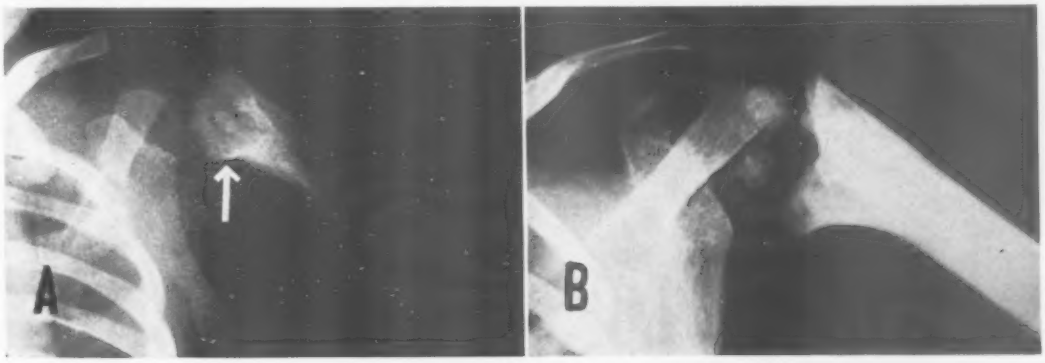

Fig. 12. Case vii. *A*, July 13, 1940. Destruction of bone in the proximal humeral metaphysis with circular sequestrum in the center of the shaft (arrow). No epiphyseal center is seen. *B*, March 18, 1943. Residual deformity of the metaphysis with absorption of sequestrum. Two epiphyseal centers of the proximal humerus are visible. Sclerosis of the shaft.

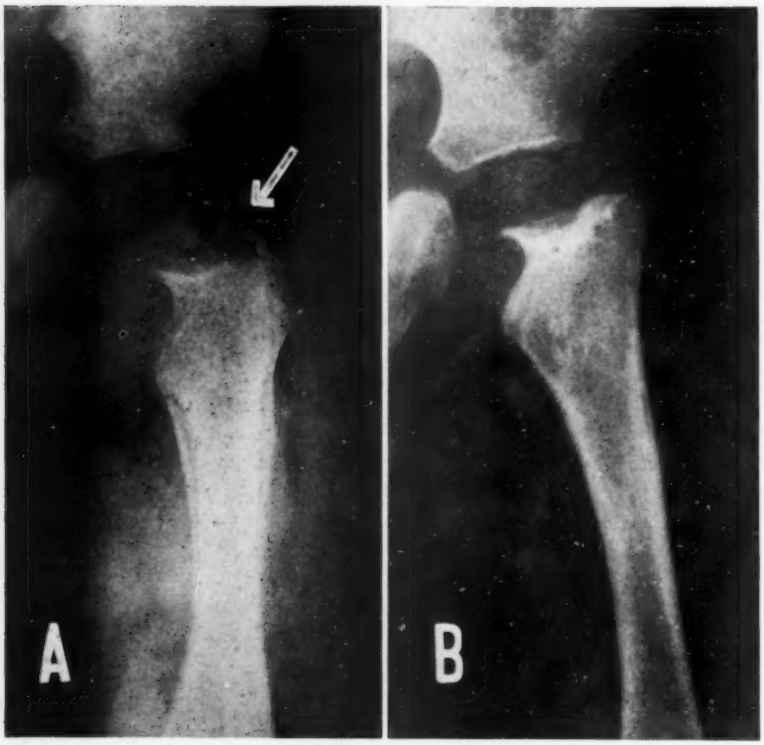

Fig. 13. Case viii. *A*, April 19, 1944. Widening of the joint space, area of destruction in the metaphysis (arrow) and periosteal elevation. The epiphysis is barely visible and appears partly decalcified. *B*, August 18, 1944. Metaphyseal outline is smooth and the joint space is of normal width. The epiphyseal center has disappeared.

Fig. 14. Case viii. November 16, 1944. Residual instability and subluxation in the left hip.

ually over a period of nearly three years. The sclerosis of the humeral shaft indicates a chronic osteomyelitis. This is the only case in which the course of the disease was similar to that seen in the older age groups.

Case viii. R. K., male (44-3824), aged nine months, admitted April 19, 1944. At the age of six months the child developed a protracted upper respiratory infection complicated by otitis media. Pneumonia developed at six and one-half months and at that time swelling and redness over the left hip joint were noted. Sulfadiazine was given and the child became afebrile but the extreme tenderness and swelling remained. On March 16, 1944, an incision was made in this area but no pus was obtained. Subsequently the swelling decreased slightly but the tenderness remained. The temperature was elevated only occasionally.

On admission the hip was held in 110° flexion and 90° external rotation. Motion was free but painful. The incision was healed. The general condition was good.

Temperature was 102.4° F., hemoglobin 11 grams and the white blood cell count 17,500.

Roentgenogram showed subluxation of the left hip, an area of destruction in the metaphysis and periosteal elevation. The epiphyseal center was small and irregular (Fig. 13*A*).

Treatment consisted of a hip spica plaster of paris cast for two months followed by a brace. Progress roentgenograms revealed healing in the metaphysis (Fig. 13*B*). The epiphysis was not visible on November 16, 1944 (Fig. 14). Flexion of the hip was limited to 30°, abduction to 15° and adduction to 35°. The child was clinically well.

Comment. This case demonstrates the rule that pyarthrosis commonly occurs when the osteomyelitis develops in the proximal femoral metaphysis. Of interest is the speed of the complete dissolution of the head of the femur.

Case ix. T. P., male (39–92), aged seven months, admitted January 13, 1939. The infant had diarrhea at the age of three weeks followed by pneumonia at two months. Two weeks later swelling of the right thigh was noted. This was incised and pus was obtained.

On admission the child was undernourished. The entire right thigh was swollen and pus exuded from two rubber drains. The thigh was held in flexion. There was pain on extension.

The temperature was 98° F., hemoglobin 10 grams and white blood cell count 11,460.

Roentgenograms showed an irregular area of destruction in the roof of the acetabulum and periosteal elevation of the femur. The capital epiphysis was not visible.

Treatment consisted of adequate drainage and immobilization. Progress was satisfactory

Fig. 15. Case ix. April 15, 1941. Final roentgenogram showing a shallow acetabulum with an oblique and irregular roof. Subluxation of the hip with absence of the femoral epiphysis.

with gradual healing of the sinus. Follow-up roentgenograms showed a shallow acetabulum with subluxation of the femur. The last roentgenograms on May 20, 1943, revealed absence of the capital epiphysis (Fig. 15). The child walked with a limp. Limitation of motion in the hip joint was present and there was a shortening of 1 inch.

Comment. An upper respiratory infection was again the source of the infection. The rapid destruction of the bony tissue about the hip was demonstrated in this case—four months after the onset.

Case x. J. P., male (J-1667), aged six months, admitted February 23, 1934. Early medical history was not significant. At the age of four and

Fig. 16. Case x. April 17, 1935. Final roentgenogram showing bilateral deformities of the acetabula. On the left there is destruction of the epiphysis and subluxation. The small shadow adjoining the metaphysis on the right may be delayed development of the epiphysis.

one-half months the infant developed high fever and enlarged cervical lymph nodes. One week later it was noted that he held both thighs in flexion and splinted the left arm. The left shoulder area was drained in a local hospital. A week later the right hip region was opened and a large amount of pus liberated. Additional areas of swelling in the left side of the neck, right wrist, right axilla and left hip were drained. Paracentesis for left otitis media was performed.

On admission pus could be expressed from sinuses in both hip regions. The remaining wounds were healed. The infant had bilateral otitis media.

Temperature was 102° F., hemoglobin 8 grams and the white blood cell count was 38,100. Blood culture was negative.

Roentgenograms revealed normal shoulder and wrist joints. There was destruction in both acetabula, more marked on the right side, with loss of the capital epiphysis and mild destruction in the proximal portions of both femoral metaphyses. The hip joints were subluxated.

The left hip joint was drained on March 2, 1934, and a large amount of pus liberated. Traction was applied to both lower extremities. Temperature gradually returned to normal and drainage ceased within the month.

Progress roentgenograms showed gradual healing. Final roentgenograms on April 17, 1935, revealed deformities of the acetabula with destruction of the capital epiphysis on the left. A small capital epiphysis was seen on the right (Fig. 16). At that time all joints were freely movable. The gait, however, was unsteady.

Comment. Presumably the focus of infection was in the upper respiratory tract. The infant developed numerous metastatic abscesses involving apparently only the soft tissues with the exception of both hip regions. Bilateral hip involvement is unusual. The destruction was more extensive on the left. The appearance of the right capital epiphysis was delayed.

DISCUSSION

It is generally accepted that osteomyelitis in infants has a different course than in older age groups. It is difficult, however, to fix the age at which this change occurs. We

selected infants in whom the illness began before they reached the age of six months, while other observers have included infants up to one or two years of age. There is, however, definite indication that with the advancing age of the infant the disease will resemble more and more the infection in older children. In our series the infections were relatively benign and the pathologic changes were often reversible if the diagnosis was made early and adequate treatment instituted.

Other authors have stressed the higher incidence of streptococcus infections in infants. Our series does not offer sufficient bacteriologic data to be significant, as the primary drainage was carried out elsewhere in many cases. In 2 instances in which penicillin had been given the cultures were negative.

Certain anatomic factors in the infant allow early natural decompression of the metaphyseal abscess, either into the subperiosteal space or the neighboring joint. The latter usually depends upon the joint which is involved. It may be difficult to retrace the course of the infection when the joint is involved at the time of the first examination. The possibility of primary suppurative arthritis must occasionally be considered. When Cases IX and X were first seen in our hospital they revealed destruction of the capital epiphyses, acetabula and metaphyses. The clinical and roentgenographic courses, however, were similar to those in other cases and we believe that the infection was primarily an osteomyelitis.

Six of our 10 cases had a history of upper respiratory, umbilical or cutaneous infection, while the mother of one had a breast abscess. These observations are in accord with those of others who described similar infections accounting for the bacteriemia and subsequent osteomyelitis.

Local swelling and malfunction of an extremity were usually the first signs. Systemic manifestations were minimal, even though in several cases the lesions were multiple at the onset. Rapid improvement occurred after decompression of the soft tissue abscesses. Drainage from the abscesses subsided within three to twelve weeks.

The earliest roentgenograms revealed areas of rarefaction in the metaphyses. Periosteal elevation was usually present. In some cases, healing of the lesions was noted on admission. In all cases, the roentgenograms offered an excellent opportunity to study the course of the infection.

Destruction of the epiphyseal cartilage, epiphyseal center and cartilage of the joint seems to be the most common and most serious complication, as it is followed by a disturbance of growth of enchondral bone with ultimate deformity. A persisting sequestrum was seen in only 1 case.

Treatment consisted of immobilization and supportive measures. Drainage of one or more abscesses was performed in 8 cases. In no instance was a direct surgical attack upon the bone necessary for drainage. One case received penicillin and another sulfonamides without surgical interference. Drainage was combined with chemotherapy in 4 patients. The small number of cases does not allow us to draw conclusions regarding the type of chemotherapy which promises better results. We believe that all soft tissue abscesses should be drained early and that penicillin should be administered. In cases with associated suppurative arthritis early drainage will minimize the destruction of the joint. In addition, all affected extremities should be immobilized and supportive measures instituted.

SUMMARY

1. Ten cases of osteomyelitis in infants under six months of age are reported.

2. The benign course of the disease and its differences from the disease in older children are emphasized. The pathologic process was reversible in several cases and the clinical recovery in all cases was complete.

3. Roentgenograms are invaluable in detecting the presence of the disease, in following its different phases and in evaluating the end-results.

4. Involvement of a joint is common and is the most serious complication.

5. Good treatment consists of: (*a*) supportive measures; (*b*) early, adequate drainage of the soft tissue abscesses; (*c*) immobilization; (*d*) chemotherapy.

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THE OCCASIONAL APPEARANCE OF BOTH INNER AND OUTER SUTURE LINES IN ROENTGENOGRAMS OF THE SKULL SIMULATING FISSURE FRACTURE

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THE anatomical fact of the existence of separate suture lines for the outer and the inner tables of the calvarium has been given comparatively little consideration in the roentgenological, surgical and anatomical literature. Since it has led to the erroneous diagnosis of fissure fracture of the skull, it is worthy of discussion. Many textbooks on roentgen diagnosis, including those dealing exclusively with roentgen diagnosis of the skull and diagnosis of fractures, fail to mention this anatomical detail. No specific paper dealing with this subject was discovered in the literature of the last decade; however, illustrations with correct description of the double suture line have been published by Dyke[1,2] and by Schwartz.[5,6]

Analysis of illustrations of the calvarium in anatomical textbooks such as in Spalteholz' "Hand Atlas of Human Anatomy,"[7] reveals a surprising difference in the appearance of the two sutures. The sutures of the inner table form comparatively straight lines while the sutures of the outer table present the well known serrated appearance. This difference is equally well demonstrated on the specimen of a skull (Fig. 1,

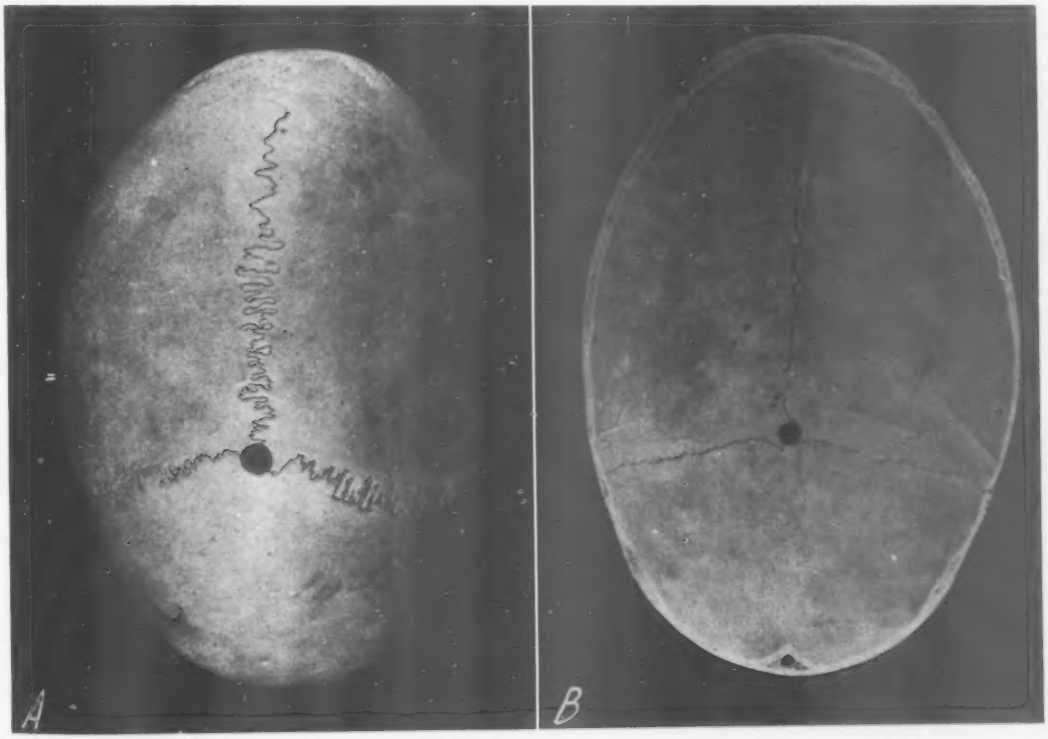

Fig. 1. *A*, normal dried specimen viewed from the outer surface demonstrating the serrated external suture lines. *B*, photograph of the inner surface showing the comparatively straight internal sutures.

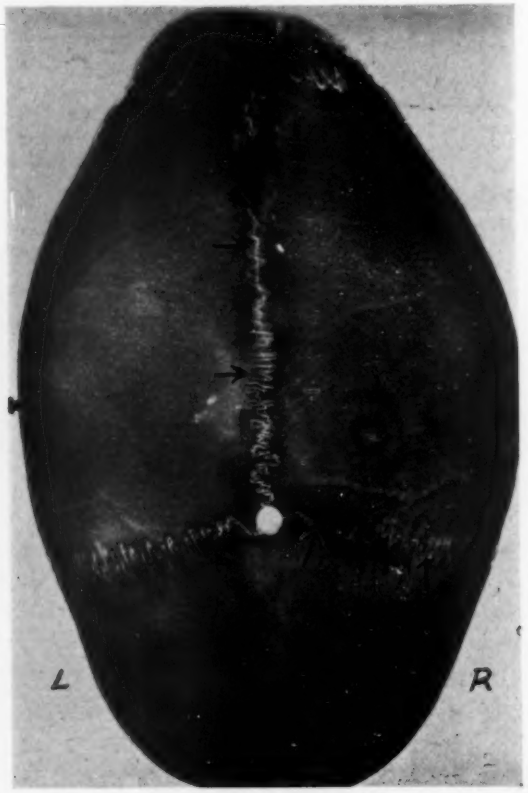

Fig. 2. Roentgenogram of the same skull photographed in Figure 1, showing "double suture lines" in the sagittal and right coronal sutures.

A and *B*). A roentgenogram of the same dried specimen (Fig. 2) shows both suture lines superimposed with the straight sutures of the tabula interna crossing the meanderings of the external suture lines.

In routine skull roentgenograms this "double suture line" is most frequently seen in the sagittal suture and the medial portions of the coronal and lambdoid sutures. It may appear in other sutures and is not necessarily symmetrical. It is most clearly demonstrated where there are other sutural variations, such as the persistent frontal (metopic) suture.

The illustrations (Fig. 3, *A* and *B*) show these double lines in a patient with no history of any previous injury to the skull. The roentgenogram reproduced in Figure 4. *A* was taken following an epileptic attack and diagnosed at another hospital as a "linear fracture of the anterior portion of the left parietal bone." In this department the suspected line was considered to be a double suture line; this interpretation is given added strength by the demonstration in the same patient of another double suture line along the sagittal suture (Fig. 4*B*).

In personal discussions with competent specialists in various fields, lack of familiarity with this anatomical curiosity was

Fig. 4. *A*, erroneous diagnosis of "fissure fracture of the skull" in a case of double suture lines of the coronal suture. *B*, demonstrating the presence of double lines over the sagittal suture of the same patient.

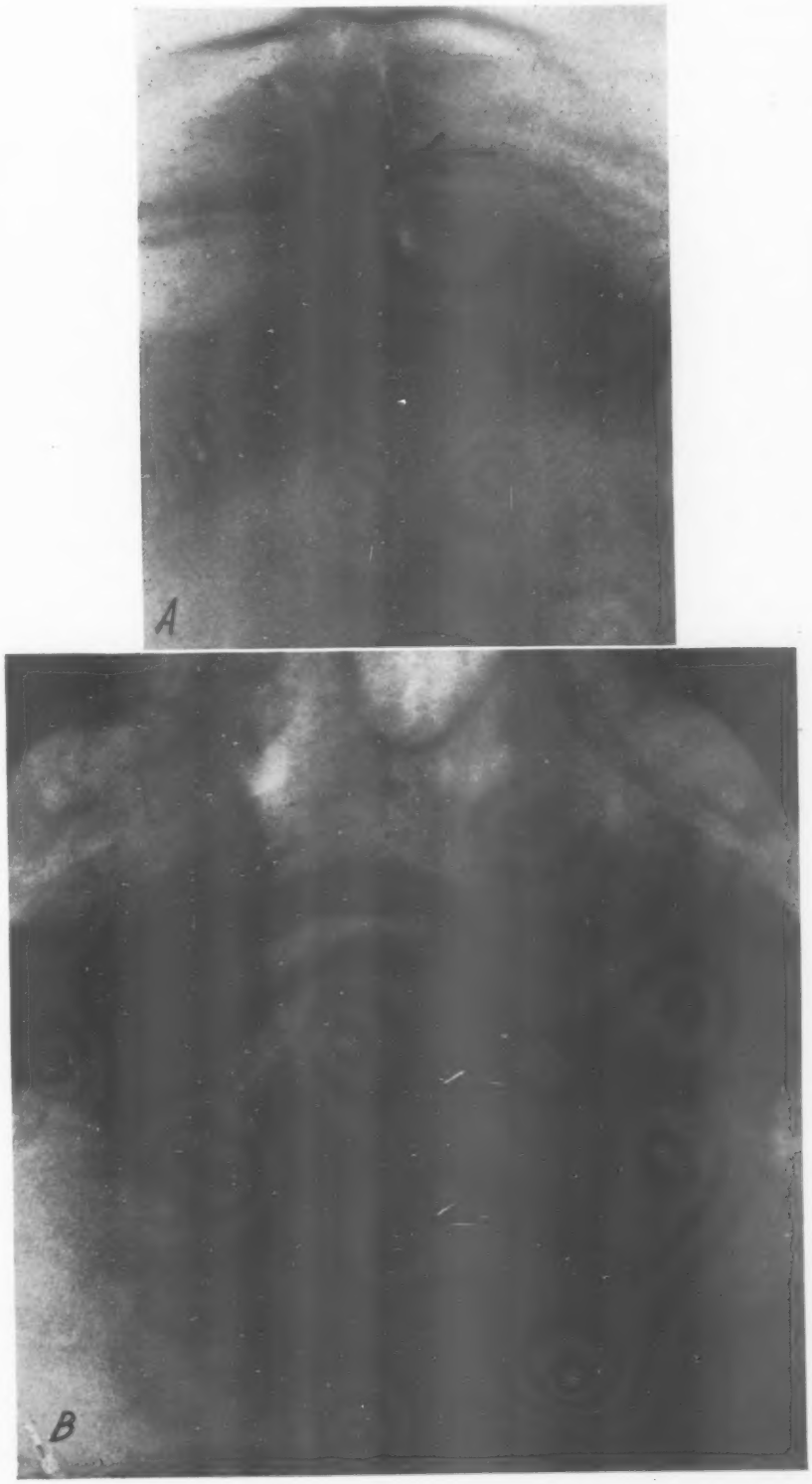

Fig. 3. *A*, double lines of the sagittal suture seen in the anteroposterior projection. *B*, demonstrating the same lines in the submentovertical base projection.

evident. Again repeated erroneous diagnosis of fissure fracture of the skull based on roentgenological demonstration of these double lines was encountered. Therefore it seems appropriate to re-emphasize this anatomical relationship in order to avoid diagnostic errors.

CONCLUSIONS

1. Anatomical and roentgenological illustrations demonstrating the phenomenon of the "double suture lines of the skull" are presented.

2. The origin of these double lines is analyzed as being caused by the superimposition of the comparatively straight inner sutures upon the serrated outer suture lines.

3. A warning is issued against the erroneous diagnosis of a "fissure fracture of the skull running along the suture" and a pertinent case is illustrated.

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DUPLICATION OF THE ENTIRE LARGE INTESTINE (COLON DUPLEX)

REPORT OF CASE*

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EARLY in October, 1944, a healthy looking, rather corpulent young woman was referred by a medical consultant of the Mayo Clinic to the Section on Roentgenology for examination of the large intestine. The consultant noted only that she had been suffering from obstipation. Proctoscopic examination performed the day before had revealed that the rectum and lower portion of the sigmoid colon were normal except that they were displaced markedly toward the right side by what was thought to be a mass in the left side of the pelvis.

Preliminary roentgenoscopic inspection of the abdominal field revealed nothing abnormal. After the contrast enema was begun, it was evident that the rectum was displaced toward the right side and the dim outline of a pelvic mass could be seen. No other roentgenoscopic evidence of intestinal abnormality was elicited. Posteroanterior and anteroposterior roentgenograms of the abdomen were made after the patient had expelled the bulk of the contrast enema (Fig. 1). Immediately thereafter the colon was redistended with air in an attempt to determine more adequately the anatomic relation of the pelvic mass to the rectum and sigmoid (Fig. 2*a*). A diagnosis of duplication of the entire colon was made.

The supernumerary colon, which contained a material impervious to roentgen rays, was visible on the roentgenograms. We were and still are convinced that the material in the supernumerary colon was not a part of the contrast enema because its concentration was so uniform throughout, and because the lumen containing it could be shown to communicate neither with the normal colon nor with the outside of the body. Since the excretion of calcium occurs chiefly through the mucous membrane of the large intestine, we reasoned that the opaque element in this material was calcium, and that it was concentrated in the anomalous colon because the mucous membrane retained its function of excreting calcium even without a channel through which to eliminate it. The extra colon had a well formed rectal ampulla and sigmoid loop. Its course ran parallel to that of the normal colon throughout; the rectal, sigmoidal, descending, cecal, and ascending portions lay lateral to, and the transverse portion above, the analogous normal portions (Fig. 2*b*). The anatomic relationship of the two lumens was obviously intimate. Along the inferior border of the lumen of the normal colon a short crescentic deformity was visible (Fig. 1 and 2*a*). The cause of this was not determined preoperatively, but after the operation we decided that it was probably a site of reaction in the region where surgical drainage had been instituted elsewhere before the patient came under our observation.

The patient was a married woman, aged twenty-seven, who since the first week in September, 1944, had been having attacks of sharp pain across the lower part of the abdomen accompanied by obstipation. The obstipation was

* Read at the annual meeting of the Minnesota Radiological Society, St. Paul, Minn., May 26, 1945.

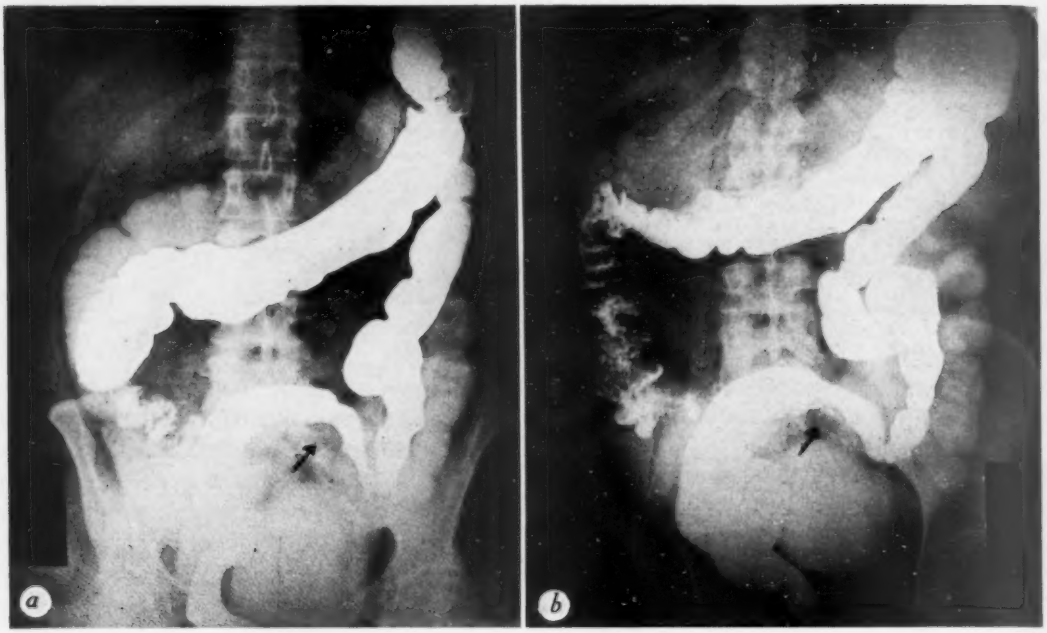

FIG. 1. *a*, anteroposterior and *b*, posteroanterior roentgenograms of the colon after the contrast enema was expelled. The denser shadow is the normal colon showing the rectum displaced toward the right side and the sigmoid colon elevated by the pelvic mass made up of the ampulla of the extra rectum and sigmoid colon. The arrows point to the crescentic deformity referred to in the text. The course and contour of the duplicated colon are best shown in *a*.

so severe that emptying of the intestine was accomplished only with the use of enemas. On one occasion she took a laxative which did not relieve the pain she was having although it did promote defecation. Two days later her temperature rose to 107° F. and she had chills. The patient was taken to a hospital, was given fluids by the intravenous route and a hypodermic injection of a sedative. Her temperature returned to normal after a short interval. During the attacks the patient noticed much rumbling in the abdomen. She was always able to pass gas by rectum but she was never able to pass feces without the use of enemas. She also noticed that it was becoming progressively more difficult for her to expel enemas, chiefly because the abdominal pain and cramps were increasing steadily in severity. Blood was never noticed in the stool. The patient had been nauseated but she had never vomited. In the final six weeks before registration at the Clinic she had lost 20 pounds (9.1 kg.).

There had been several similar attacks of abdominal difficulty before the onset of this series of events. The patient was seen at the Clinic in 1919 when she was eighteen months old. At that time congenital dislocation of the right hip was reduced successfully by manipulation and application of a double spica cast. In 1921, when the patient was three years old, she was operated on elsewhere for acute intestinal obstruction. The surgeon relieved what he called a "kink" in the region of the sigmoid flexure and created an opening into what he thought at the time was the colon but which he subsequently came to believe was a mesenteric cyst. In 1937, when the patient was about nineteen years old, the same surgeon operated on her again, this time for acute appendicitis. He removed two appendices, both from the tip of the cecum, one of which was gangrenous. The abdomen was not explored at that time because of the acute inflammatory condition of the appendix. Three years later, in 1940, the same surgeon explored the abdomen, this time because of symptons of partial intestinal obstruction. He tried unsuccessfully to remove what he thought was the mesenteric cyst so he again drained it. Recovery was satisfactory, but a cutaneous fistula which opened and closed at intervals persisted in the abdominal scar. When draining, it usually yielded serous fluid but

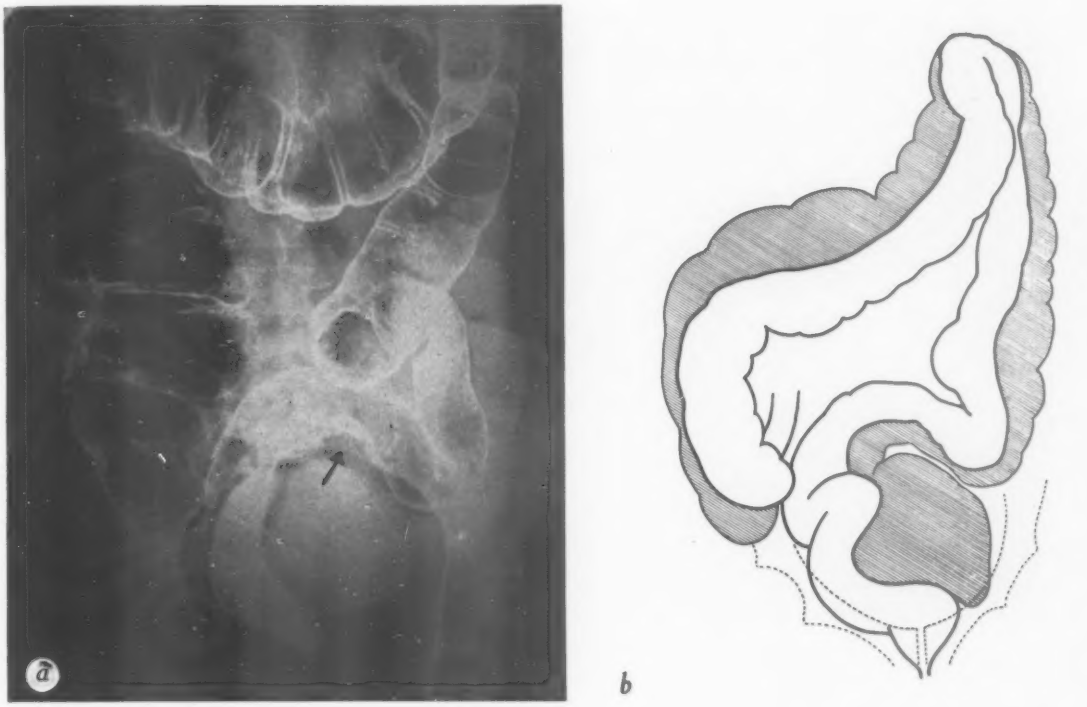

FIG. 2. *a*, anteroposterior roentgenogram of the colon after redistention with air. The duplicated colon is not clearly shown but the distention of the normal colon is well shown. The arrow points to the crescentic deformity referred to in the text. *b*, Diagrammatic interpretation of the roentgenograms.

there were times when gas and liquid feces emerged through the opening. In other respects the patient remained well until the renewed onset of symptoms in 1944 when the surgeon observed an enlarging pelvic mass.

The patient gave a normal menstrual history. In a letter to the Clinic the surgeon noted that the patient had a double uterus and double cervix, and that she had had two early miscarriages. Her husband, twenty-five years of age, was living and well. The family history revealed nothing pertinent.

Physical examination revealed a well developed, somewhat obese woman in apparent good health. The temperature was 98.2° F. The systolic blood pressure was 130, the diastolic 90 mm. of mercury. The breasts were normal. Several abdominal scars were noted. Deep pressure over one of the scars in the right inguinal region elicited tenderness. The colon was palpable. Digital examination of the rectum and manual examination of the pelvis through the vagina revealed no abnormalities.

Examination of the urine was essentially negative. The blood at the time of examination contained 13.1 gm. of hemoglobin per 100 cc.; there were 4,690,000 erythrocytes and 8,500 leukocytes per cubic millimeter of blood. The results of proctoscopic and roentgenologic examinations of the intestine have been described. Roentgenographic examination of the chest revealed no abnormal findings. Cholecystography was attempted four days after the roentgenologic examination of the colon was completed. The functioning colon was filled with gas and the nonfunctioning colon contained enough of an opaque secretion to make satisfactory interpretation of the cholecystograms impossible. Intravenous urography was attempted the following day, but interpretation of the excretory urograms was considered to be unsatisfactory because of the large amount of gas in the functioning colon and because of the opacification of the nonfunctioning colon with the shadow-casting material it contained (Fig. 3*a* and *b*). No part of the right kidney or right ureter was made visible by the urographic contrast material but the pelvis of the left kidney was made

FIG. 3. Excretory urograms made five days after the roentgenologic examination of the colon: *a*, five minutes after injection of urographic medium and *b*, twenty minutes after injection of urographic medium. The normal colon is moderately distended with gas; the duplicated colon contains the same concentration of opaque material which was shown in the roentgenograms of the intestine. No shadow of kidney or ureter is seen on the right side; the pelvis of the left kidney and a portion of the left ureter may be seen at the level of the fifth lumbar vertebra. Cholecystographic examination had been done the day before; the dye-laden gallbladder is projected over the hepatic flexure of the colon on *a*.

visible as was the left ureter throughout most of its course.

Surgical exploration was advised with the idea of removing the supernumerary colon. On October 17, 1944, surgical exploration was undertaken by one of us (C. F. D.). A primary lower left rectus incision was made. Duplication of the entire colon with a common mesentery was found. The colon seemed to be about five to six times larger than normal, and the presence and the position of the longitudinal bands of the cecum and ascending colon established the fact of duplication there. The colon continued as a double organ in this manner around to the middle of the descending colon where the two colons became more distinctly separate. The vascular supply originated from the same mesentery. The most lateral portion of intestine extended down to a point just below the pelvic peritoneal fold, where, as nearly as could be determined, it ended blindly (Fig. 2*b*). This lateral segment was distended about six to eight times the size of a normal colon. A tube passed into the rectum entered the mesial portion of the duplicated bowel not the lateral segment. In the region of the first portion of the sigmoid, there was evidence of active inflammation where the lateral or blind end of the bowel had been drained previously (Fig. 1 and 2*a* at arrows). This was the site of communication of the cutaneous fistula, and in this immediate region there was also a narrow fistula, 2 or 3 mm. in diameter, running an oblique course between the normal colon and the supernumerary one. Since there was marked inflammatory reaction in this vicinity, the descending and sigmoid portions of both colons were freed from the abdominal wall, and about 8 to 10 inches (20.3 to 25.4 cm.) of each was resected after exteriorization and application of clamps. A future operation was anticipated at which time the continuity of the colon would be re-established and the spurs would be crushed in two directions in order to have the blind end of the bowel empty properly. Further exploration of the abdomen revealed the liver and gallbladder to be normal. There was no evidence of a kidney on the right side. The left kidney which was in normal position seemed by palpation to be about one and a half times normal size. Explora-

Fig. 4 *a* and *b*. Roentgenograms of the abdomen six months after operation. Other than gas-containing loops of large intestine, especially in the region of the splenic flexure, the roentgenograms reveal nothing abnormal.

tion of the pelvis revealed two infantile uteri.

MacCarty reported as follows on the specimen of 15 cm. of large intestine delivered to him for examination: "The specimen consists of two segments of large bowel, attached to each other throughout their length. One segment appears to be normal colon. The other is somewhat narrower and shows areas of superficial ulceration."

At the time of the second operation, surgical re-establishment of the continuity of the exteriorized loops of the two colons was accomplished by end-to-end anastomosis, producing what is essentially a colocolostomy in the mid-sigmoid.

The patient was seen at the Clinic again on May 15, 1945. She was still having some minor abdominal distress but seemed to be in excellent health in other respects. Roentgenographic examinations of the abdomen revealed that the remainder of the supernumerary colon no longer contained any visible opaque material (Fig. 4). With the exception of small collections of intestinal gas along the course of the large intestine, the examination of the abdomen was negative. A roentgenologic examination of the intestine with the use of contrast material was not attempted at this time.

REVIEW OF LITERATURE

We reviewed the available literature on conditions of this kind as completely as our facilities permit. Reports of duplication of the small intestine are relatively frequent. No instance was found of a duplication of the large intestine in which the supernumerary intestine had no communication with the small intestine above it nor with the outside via the rectum. This is the only example we were able to find in which duplication of the entire colon was demonstrated roentgenologically. It is also the only instance in which a correct preoperative or prenecroscopic diagnosis of the condition was made.

Duhem and Monmignault, in 1936, published roentgenograms they made of a three year old child who had a duplication of the rectum and sigmoid; the patient had two anal openings, both functioning simultaneously, two vaginas and two permeable vulvae. When a colored solution was injected into one anus it came out of the other. Injection of contrast suspension

into the left anus filled a cavity which looked like a rectal ampulla; when the material was injected into the right anus it filled the cecum. Ombrédanne made a report of the same case in the same year. Ballance operated on a patient who had an imperforate anus. At the operation he discovered that there was a complete duplication of the colon extending from the rectum "nearly or quite as far as the cecum." This patient was a ten year old girl who had two rectal orifices opening into the lower and posterior vaginal wall on both sides. Injection of contrast suspension into these openings showed that there were two rectums and sigmoid colons but the rest of the colon was not outlined on the published reproduction of the roentgenograms. Gray reported an instance of triplication of the colon in an infant who was admitted to a hospital when one week old and who died nine months later. The diagnosis was made at necropsy. Grohé, in preroentgenologic times, reported the case of a young girl who was discovered, in a series of laparotomies, to have a complete duplication of the large intestine complicated with many genitourinary congenital anomalies. Asai, a Japanese, also reported a case of duplication of the large intestine, the diagnosis having been made at laparotomy.

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CLUBBED FINGERS*

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THE purpose of this communication is to report certain roentgenologic findings in the arteries and arterioles, as well as to show the infra-red photographs of the superficial vessels in clubbed fingers.

MATERIAL AND METHOD

The material studied consisted of 6 cases of bilateral clubbed fingers. In 3 cases, at autopsy, the brachial arteries were injected with a suspension containing 90 gm. of barium sulfate and 180 cc. of water, after which roentgenograms were made of the hands. In 2 cases, the superficial vessels were photographed, using an infra-red filter.

CASE REPORTS

CASE 1. The patient was a woman, aged twenty-five, who died of fibroid pulmonary tuberculosis. Bilateral clubbing developed about three months prior to her death. When compared with the arteriogram of the fingers without clubbing (Fig. 1), the arterioles in this case are more numerous and prominent about the terminal phalanges, forming a comparatively heavier network about the finger tips (Fig. 2 and 3).

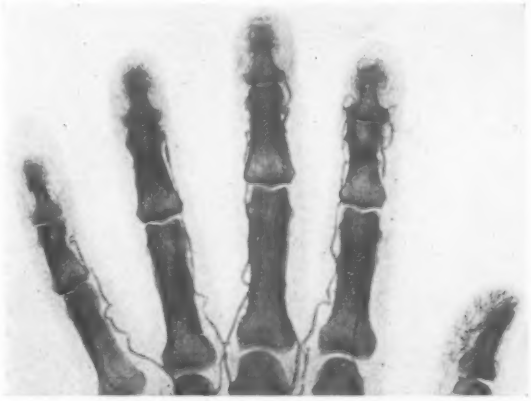

FIG. 1. An arteriogram of the normal hand without clubbing of the fingers.

FIG. 2. An anteroposterior arteriogram of the hand in Case 1.

FIG. 3. An oblique arteriogram of the hand in Case 1.

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Fig. 4. An anteroposterior arteriogram of the hand in Case II.

Case II. The patient was a woman, aged thirty-five, who died of fibroid pulmonary tuberculosis with a tuberculous empyema. The clubbing developed in both hands about six months prior to her death. Again the terminal arterioles appeared comparatively more numerous and dilated than in the normal control (Fig. 4 and 5).

Case III. The patient was an anthracite coal miner, aged forty-five. He had far advanced anthracosilicosis with superimposed ulcerocaseous pulmonary tuberculosis. The clubbing was not prominent; it developed about six months prior to his death. The multiplicity and fullness of the terminal phalangeal arterioles are again evident (Fig. 6).

Case IV. The patient is a man, aged forty, who is now under treatment for far advanced bronchiectasis. The infra-red photograph of his hands (Fig. 7) shows that the superficial vessels are more numerous and engorged than in the control patient without clubbing (Fig. 8). There was no evidence of congestive heart failure.

Case V. This patient is a man, aged twenty-five, who has congenital stenosis of the pulmonary artery with a possible interventricular septal defect. Recently he developed exudative pulmonary tuberculosis. The vessels of the fingers are dilated and engorged (Fig. 9). When the arms are elevated the vessels almost completely empty and the balls of the clubbed fingers become shriveled. When the arms hang again, the vessels become engorged and the finger tips bulbous. The patient always has considerable cyanosis, but no signs of myocardial insufficiency.

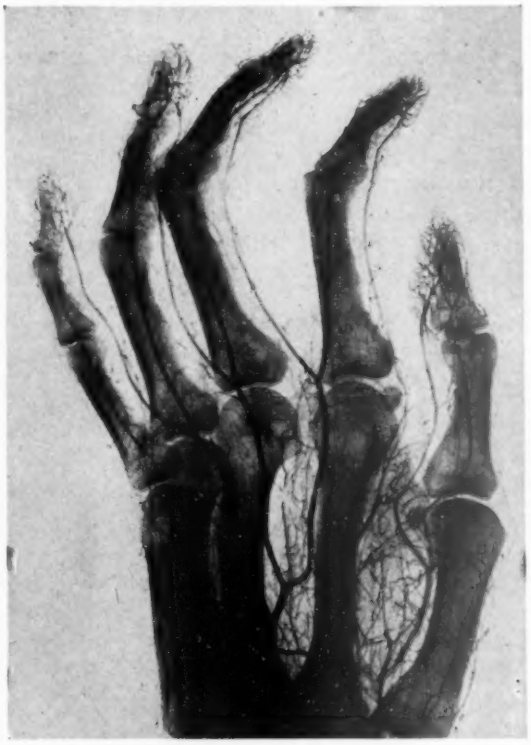

Fig. 5. An oblique arteriogram of the hand in Case II.

Case VI. This man, aged forty-two, was a patient of Dr. M. J. Sokoloff. He developed pulmonary necrosis of the left upper lobe following two attacks of what appeared to be virus pneumonia. The earliest change in the fingers was erythema of the nail beds and the thenar and hypothenar eminences of the palms. Gradually the finger tips became bulbous and the nails curved. As the necrosis of the left lung became more extensive, he developed high and irregular fever varying between 101 and 103°F. The palms perspired almost continually.

Fig. 6. An anteroposterior arteriogram of the hand in Case III.

Early in the morning, when the temperature was relatively low, urticaria appeared on the erythematous thenar and hypothenar regions of the palms associated with considerable pruritus. The urticaria recurred almost daily only on the palms until the time of lobectomy following which he died.

DISCUSSION

The roentgenologic studies in clubbed fingers thus far have dealt with the changes of the bones. The conclusions drawn have been briefly these: In the early stage there is no change of any sort.[17] In the advanced cases, increased flare of the ungual process of the terminal phalanges was noted.[12] If clubbing developed during the growing period, the terminal phalanges became hypertrophied and longer than normal,[18] especially in unilateral clubbing with venous stasis.[22] In the far advanced stage, osteoporosis[10] or complete resorption[19] of several or all the terminal phalanges was seen. Hypertrophic osteoarthropathy of the bones of the hands with proliferation of subperiosteal new bone was a common picture. Occasionally the terminal phalanges were encapsulated with newly formed periosteal bone.[13]

Fig. 8. An infra-red photograph of normal hands.

In the present study on recent clubbing without osteoarthropathy, the roentgenologic studies were made with a view to demonstrate possible arterial changes in the clubbed fingers. Attempts were made to demonstrate the status of the vessels in the living by means of an opaque material (diodrast) injected into the radial arteries, but certain technical difficulties prevented obtaining satisfactory roentgenograms of the fingers. The rapidity of dilution of the

Fig. 7. An infra-red photograph of the hands in Case IV.

Fig. 9. An infra-red photograph of the hands in Case V.

opaque material and the difficulty of rapid injection made contrasting densities poor; moreover, there was difficulty in synchronizing the time of exposure with the injection. We therefore turned to the more established method, using barium.

The postmortem arteriograms showed that the arteries and arterioles were more numerous, their lumens wider, and the ungual processes were covered with a heavier network of arterioles. The infrared photographs of the clubbed fingers demonstrate greater prominence and number of the superficial vessels than normal. In the case with congenital heart disease, the increase in the soft tissues about the terminal phalanges was found to be in direct proportion to the degree of engorgement of the vessels.

The findings in these 6 cases substantiate the previous anatomic studies[26] which have shown dilatation and increased thickness of the vessel walls as well as a new formation of capillaries,[27] increase in the tissues of the finger tips, particularly in the fibrous elastic tissue of the nail beds,[31] increase in the area of the nail and skin corresponding with the increase in volume of the underlying tissues,[1] increased thickness of the epidermal tissues,[32] of the periosteum and of the ungual process of the bone itself.[35] Atrophy of the bone 14 had been noted in the later stages when studying the tissue sections.

Studies have been made to determine the state of blood flow in the clubbed fingers with somewhat conflicting findings. Capillary stasis with decreased blood flow and constriction of the capillaries were noted.[11] Dilatation and even aneurysmal loops were seen in others.[28] A determination of the skin temperature by means of the thermocouple showed lowered temperature in the clubbed extremity, suggesting decreased blood flow. Just the opposite findings have been encountered by others.[22] These variations might have been due to different physiologic conditions present at the time of the studies, such as temperature, fear, and other emotional factors. Under regulated conditions of the environmental temperature and emotions with a relaxation of sympathetic tone, the colorimetric determinations showed increased blood flow per square centimeter in the finger tips.[22] In a patient with lung abscess in which clubbing disappeared after the recovery from the disease, the blood flow was shown to return to normal.[22] The antecubital venous[16] and the brachial arterial[23] pressures in symmetrical clubbing were normal. The thought that the clubbing is largely hypertrophy and hyperplasia as a result of overnutrition brought about by increased peripheral blood flow seems to be a popular notion at present.

Attempts have been made to produce clubbing in experimental animals. Introduction of exudate from pulmonary abscess into the rectum,[2] intravenous injection of tubercle bacilli and other pyogenic organisms,[8] paraffin injection into the lungs,[5] ligation of the bronchi and chronic congestion[33] all failed to produce clubbing.

Hypertrophic osteoarthropathy has been produced experimentally in a dog by anastomosis of the left pulmonary artery to the left auricle. This produced a lesser circuit shunt simulating the circulatory status seen in congenital heart disease with cyanosis. The shunts were not followed by any changes of the circulation time, venous pressure, or oxygen consumption. The outstanding finding was an increase in systemic cardiac output, the blood flow through the lungs remaining comparatively normal.[24]

Many theories have been advanced on the pathogenesis of clubbed fingers. Emaciation,[15] chronic infection,[20] toxemia,[16] capillary stasis due to back pressure from the heart and lungs,[34] local tissue anoxia,[4] malfunction of the pituitary,[9] thyroid,[21] parathyroid glands,[7] gonads,[21] nerve injury,[29] lymph stasis,[3] changes in blood volume,[25] increased intracranial pressure,[30] vitamin deficiency[6] have been considered. Future studies will have to take into consideration the facts herewith presented. The vascular changes with an increased blood flow as shown by the present roentgenologic

study will also have to be considered as an etiologic factor.

In Case VI one wonders whether the urticaria was not in some way related to histamine-like substances liberated by the pulmonary necrosis into the blood stream. It has been shown that the pulmonary parenchyma contains a considerable concentration of histamine.

SUMMARY

Six cases of bilateral clubbed fingers were studied. In three cases the arterial systems of the hands were injected postmortem with barium sulfate suspension and roentgenograms made. In two cases the superficial vessels were visualized by photographs using an infra-red filter. In one, urticaria recurred on the palms. The common finding in these cases was increased vascularity about the clubbed fingers, particularly about the ungual processes.

The etiology of clubbed fingers is unknown. The prevailing impression seems to be that the clubbing is largely a hypertrophy and hyperplasia of the tissues about the terminal phalanges as a result of increased nutrition brought about by an increased peripheral blood flow.

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VOL. 55, NO. 3

CONGENITAL DISLOCATION OF THE HIP

REPORT OF CASE

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The patient, Margaret H., was born at the Margaret Hague Maternity Hospital, Jersey City, N. J., at 6:15 A.M. on November 27, 1933, weight 2,410 grams. Because of the weight the baby was considered premature. Period of gestation was thirty-eight weeks. There was a normal spontaneous delivery. The baby was active and well nourished. Discharge from the hospital was on the eighth postpartum day. General condition was excellent. A small cutaneous depression was noted at the level of the lumbar and sacral joint, and roentgen examination was obtained of this part. That is the reason for the early roentgenograms. The report was within normal limits except for enlarged thymus. Mother and child discharged about December 6, 1933.

FIG. 1. This shows the femoral head to be in place with the acetabulum.

On June 4, 1935, at the age of one and one-half years she was brought to the Orthopedic Clinic of the Jersey City Medical Center by her mother. The child had a progressive limp and lameness noticed by her parents since she commenced to walk at the age of thirteen months. Physical examination was normal except for slight shortening of the right leg. Roentgen examination revealed a definite dislocation of the right hip. Identification was made of the patient by foot prints taken at the time of birth, by records and roentgenograms, through name, hospital charts, and parents of the patient.

FIG. 2. The acetabulum on each side looks the same. The right hip shows the femur farther from the pelvis than the left hip.

Fig. 3. On the right side there is a shallow acetabulum and a dislocated femoral head.

Three exposures are presented: Figure 1, lateral view of the hips and spine; Figure 2, an anteroposterior view of the pelvis and lower spine; Figure 3, a pelvis. The first two are exposures taken at time of birth and Figure 3 was taken at the age of eighteen months. The early roentgenograms show the relation of the femoral head to the acetabulum. On the right side the femur is farther from the pelvis than the left side; also there is slight upward displacement of the femur. Figure 3 shows a classical dislocation of the hip on the right side and a partial dislocation on the left side.

Examined so close to birth this case demonstrates that there can be a dislocation before all of the mechanical factors have crept into the picture. The acetabulum is shallow and becomes more shallow with the mechanical pull of the muscles and weight bearing. The potential factor is present for dislocation and it is aggravated by the mechanical and constitutional factors. Ossification is slow on the affected side. Physical examination is helpful only in the cases with marked dislocation. The early cases might show shortening and some external rotation. After birth the hip joint is more labile in the female. This fact could account for the partial dislocation on the left side. Heredity is not always a factor. Parents with dislocation have healthy children, while most children with dislocation have healthy parents. In this case the mother and father had no hip disease.

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GIANT JUGULAR FOSSA

WITH BRIEF NOTES ON THE ANATOMICAL VARIATIONS OF THE JUGULAR FOSSA*

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IT IS common knowledge that the jugular fossa normally shows extreme developmental variations in size, shape and symmetry. The fact that the jugular bulb lies so close to the tympanic region gives it special importance in relation to otological work. This is particularly true in the occasional case with an extremely large jugular fossa, the significance of which is aptly stressed by Stiles and Fraser in Cunningham's[1] textbook as follows:

> The floor of the tympanum is constituted mainly by the bone bounding the jugular fossa, which is occupied by the upper bulb of the jugular vein. When the sigmoid sinus is large and unusually far forward the bulb also is large; the fossa is consequently deeper, and arches up into the floor of the tympanic cavity, from which it may be separated merely by a thin and translucent plate of bone which occasionally shows an osseous deficiency. In cases where that condition existed the jugular bulb has been wounded in the operation of paracentesis of the tympanic membrane.

The warning that such accidents may happen is also mentioned in some otologic texts. Except for Mayer[2] who had the large jugular fossa well depicted in roentgenograms, there appears to be practically no mention of this condition in the roentgenological literature. The object of this report therefore is to draw the attention of roentgenologists to this relatively obscure but interesting condition.

MATERIAL STUDIED

1. *Clinical.* A patient suffering from chronic mastoiditis was seen in the Peiping Union Medical College Hospital in 1939. Details of the clinical history are, unfortunately, not available. As far as I could recollect, the patient was a young subject. A roentgenogram of the left mastoid exposed in the Law's position on March 23, 1939, showed evidence of chronic mastoiditis with moderate sclerosis. In addition, an unusual shadow in the form of an oval, homogeneous, moderately radiolucent area (shape and size of an average grape) with a well defined thin bony wall resembling a bone cyst, was seen lying just below the shadows of the acoustic meati but with its upper border partially overlapping the inferior outline of the external acoustic meatus (Fig. 1). The long axis of this radiolucent area was almost horizontal with a slight upward inclination ventrodorsally. This shadow was taken to represent an excessively large jugular fossa. The right mastoid (Fig. 2) showed no evidence of a similar cyst-like shadow. A basal or submentovertex view of the base of the skull taken a few weeks later showed up fairly clearly the very large left jugular fossa (Fig. 3).

FIG. 1. Left mastoid. The giant jugular fossa is seen as an oval radiolucent area situated just below the acoustic meati.

* From the Department of Radiology, Peiping Union Medical College, Peiping, and National Central University, Chengtu.

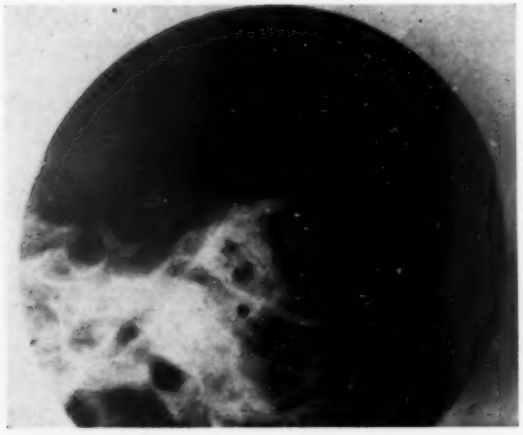

Fig. 2. Right mastoid of same case shown in Figure 1 for comparison. No similar radiolucent area seen.

A review of the mastoid roentgenograms taken in the first quarter of 1939 in the Peiping Union Medical College Hospital revealed another case with a rather large

Fig. 3. Basal view of skull of case shown in Figures 1 and 2. The radiolucent shadow of the left giant jugular fossa is seen lying lateral to and somewhat anterior to the transverse process of the shadow of the atlas.

Fig. 4. Photograph of base of skull. The right giant jugular fossa is seen lateral to the occipital condyle.

right jugular fossa, though not so pronounced as in the case described above.

2. *Anatomical.* (*a*) A collection of approximately 120 skulls in the Department of Anatomy of the Peiping Union Medical College was studied. A few skulls showed

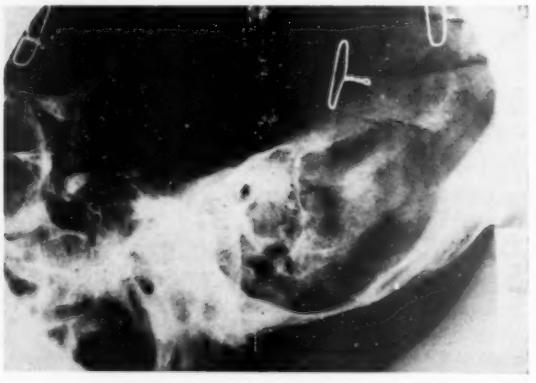

Fig. 5. Roentgenogram of right mastoid of skull shown in Figure 4. The giant jugular fossa is seen as a radiolucent area below and somewhat posterior to the acoustic meati.

large jugular fossae, but there was one skull in particular that showed an unusually large right jugular fossa the foramen of which was of oval shape (Fig. 4). From a thorough roentgenological study of this specimen, it was found that only two positions, namely, the Law and submento-vertex, offered good visualization for the large right jugular fossa (Fig. 5 and 6). Although precise figures are not available, this extremely large right jugular fossa was probably about 2 cm. wide and 2.5–3.0 cm. deep. The left mastoid of the same skull was also roentgenographed for comparison (Fig. 7).

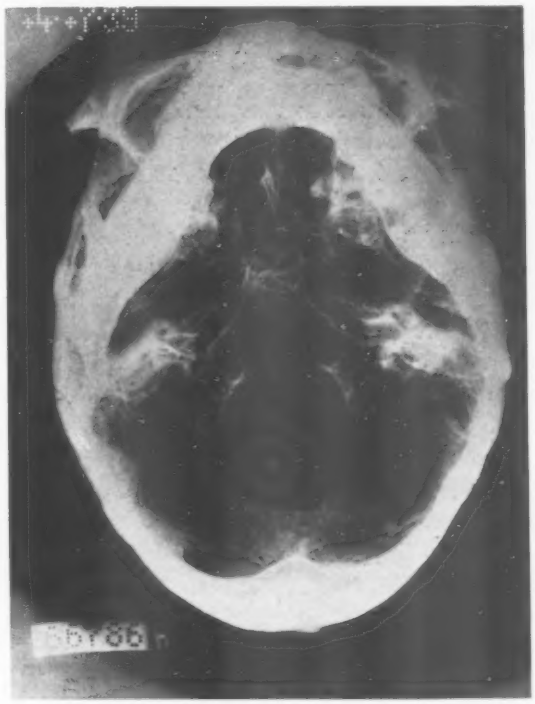

Fig. 6. Roentgenogram of base of skull of specimen shown in Figure 4. The right giant jugular fossa is clearly seen lateral to the occipital condyle.

Fig. 7. Roentgenogram of left mastoid of skull shown in Figure 4. No large oval radiolucent shadow is seen.

(*b*) Another investigation was conducted on a collection of 260 skulls in the museum of the School of Dentistry, National Central University. The results of this study (Table 1) shows that although the jugular fossa may be symmetrically developed in both sides (16.4 per cent), the right jugular fossa is larger than the left in the majority of cases (63.8 per cent), while the left fossa is larger than the right in only 20.8 per cent of cases. It is found

Table I

	a. Small Fossa (under 0.5 cm.)	b. Medium Fossa (0.5–1.0 cm.)	c. Large Fossa (over 1.0 cm.)	Total Number of Skulls and Incidence
Group 1 Jugular fossa symmetrically developed on both sides	16 skulls (40%)	24 skulls (60%)	None	40 skulls (16.4%)
Group 2 Right jugular larger than left	116 skulls (70%)	40 skulls (24%)	10 skulls (6%)	166 skulls (63.8%)
Group 3 Left jugular fossa larger than right	35 skulls (64.6%)	15 skulls (27.7%)	4 skulls (7.7%)	54 skulls (20.8%)

satisfactory to define three types of jugular fossae according to the size of their foramina, namely, (1) small (under 0.5 cm.); (2) medium (under 1.0 cm.); and (3) large (over 1.0 cm.) (see Table 1). The foramen shows considerable variation in shape, appearing in smaller fossae as fissure-like or elliptical openings, and in the larger fossae as oval or rounded apertures. The bulb or cavity of the jugular fossa is also found to vary greatly in form, from a shallow insignificant groove-like or V-shaped depression scarcely deserving the name of bulb in small fossae, to an oval, rounded or bulb-like cavity of good size in large fossae. Their interiors may be smooth or ridged, and often in the larger fossae a small rounded depression of about 2–3 mm. may be found at the topmost part or dome, the appearance of which resembles the apex of a snail's shell seen from inside.

There are 14 skulls showing large jugular fossae in this series, or an incidence of 5.4 per cent. The largest fossa measures about 1.5 cm. wide and 2.5 cm. deep. Its size, however, is mediocre when compared with the two examples described above.

Among other findings is that the transverse sinus is invariably larger in the side showing a larger jugular fossa. Also, although large jugular fossae may be found in skulls of any size, the larger fossae are usually associated with large-sized skulls.

An anomalous development is found in one right jugular fossa, namely, its foramen is completely enclosed by a ring of bone instead of being in open continuity with the foramen lacerum posterius. This abnormal foramen is rounded, and measures about 3–4 mm. in diameter.

SUMMARY

The jugular fossa normally shows considerable variation in size. Because of upward extension, the clinical significance of a large jugular fossa lies in the fact that it is apt to be punctured accidentally during paracentesis of the tympanic membrane.

An extremely large or giant jugular fossa casts an unusual grapeshaped radiolucent shadow resembling a bone cyst in roentgenograms. For roentgen demonstration of a giant jugular fossa, it is found that two views offer the best visualization, namely, the Law and the submentovertex positions.

Anatomical studies on a series of 260 skulls show that the jugular fossa is symmetrically developed in 16.4 per cent of skulls, the right jugular fossa larger than the left 63.8 per cent, and the left larger than the right 20.8 per cent. In this series, about 5.4 per cent of specimens show large jugular fossae, but there is no instance of any unusually large jugular fossa.

Based on two groups of skulls studied, the incidence of an unusually large jugular fossa appears to be about 1 in 380.

The writer is indebted to Dr. Hsu, Tien-lu of the Peiping Union Medical College and to Dr. Chen, Hua of the National Central University, for their kind permission to publish findings from their respective collection of skulls. Thanks is also due Dr. C. K. Hsieh and Dr. C. L. Hsu for other invaluable help.

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Vol. 55, No. 3

PRESENT STATUS OF ROENTGEN THERAPY OF HYPERTHYROIDISM AND RELATED ENDOCRINE DISTURBANCES*

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IN CECIL'S well known *Textbook of Medicine*[3] the chapter on the treatment of exophthalmic goiter, written by Eugene Dubois, contains the following sentences:

> The operative treatment of exophthalmic goiter is the method of choice. . . . Some of the severe cases are obviously unfit for any operative procedure on account of cardiac insufficiency. Others are in the stage of rapidly increasing severity, and an operation would precipitate a crisis. Before the introduction of the use of iodine in large doses it was necessary to wait and hope that the stormy period would pass. Some of these inoperable cases did well under x-ray treatment.

A few lines below the same author writes:

> Now the use of x-rays has been more or less abandoned, except in special cases where operation is refused by the patient or is inadvisable for some other reason.

Obviously these two statements contradict each other. If roentgen treatment is indicated in cases characterized by cardiac insufficiency and rapidly increasing severity of the symptoms, why has this treatment been abandoned in cases of less severity? In my opinion, the answer to this question is: Because medical thinking in every country and at all times has been prejudiced in favor of surgery, due to the lack of education in radiotherapy at the medical schools.

This prejudice is especially inappropriate in the United States since the roentgen treatment of exophthalmic goiter was first used by two American surgeons, Williams and Beck, in 1902 and 1905.

Today we are confronted with a new situation. In our last symposium, Dr. Goldzieher declared: "The surgery of hyperthyroidism, that is, subtotal resection of the thyroid gland, is done less and less often, and internal treatment, with or without thiouracil (a compound of the sulfa group with a urea derivative) is preferable and gives excellent results." Dr. McGavack[6] demonstrated this at the same symposium.

Thiouracil was first used in 1941 by Mackenzie and McCollum on rats affected with toxic goiter, and in 1943 Astwood administered it to patients suffering from hyperthyroidism.[6] Characteristically enough, the most recent paper on this subject, by Bartels,[1] is entitled: "Thiouracil; Its Use in the Preoperative Management of Severe Hyperthyroidism." Here, again, we find the same prejudice in favor of surgical intervention. On the other hand, in December, 1942, Soley and Stone[16] published a paper entitled: "Roentgen Ray Treatment of Hyperthyroidism" which was summarized in the AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY as follows:

> Roentgen ray treatment of hyperthyroidism has been somewhat neglected in recent years. Therefore, the authors report a series of many cases treated in this way.
>
> The results show that roentgen irradiation reduces thyroid tissue sufficiently to produce the same results as surgical subtotal thyroidectomy. The best patients for roentgen treatment are those with marked degree of exophthalmos.

On January 15, 1945, at a meeting of the Section of Ophthalmology of the Academy of Medicine of New York, Dr. M. N. Stow read a paper on: "The Relative Effects of Thiouracil, Iodine and Subtotal Thyroidectomy on the Exophthalmos of Hyperthyroidism." Stow stated (1) that an

* Read before the Medical Circle of New York City, January 19, 1945.

increase of the exophthalmos after subtotal thyroidectomy is a rule; even malignant exophthalmos may result; (2) that thiouracil also increases the exophthalmos, although to a minor degree, and (3) that iodine treatment for exophthalmos in hyperthyroidism is advisable. Dr. Ernest Gold, a surgeon of New York City, also did not very warmly recommend thyroidectomy in cases with marked exophthalmos, especially not in males whose goiter was not very large.

Neither Dr. Stow himself nor Dr. Barr nor Dr. Smelser, who confirmed Dr. Stow's statements, even mentioned the roentgen treatment of exophthalmic goiter. The authors only spoke against thyroidectomy and in favor of iodine treatment. From this quite recent paper, it is apparent that the roentgen treatment of exophthalmic goiter, and particularly of the pituitary, has fallen into such disuse that it is practically unknown here.

If it is true, as Dr. Goldzieher said, and I think he is right, that "the surgery of hyperthyroidism is in a state of decline," we may say that there are two methods of treating this ailment which are not in a state of decline: (1) roentgen treatment, and (2) the application of thiouracil, on which McGavack has given us such an impressive report.

In 1907[11] I found in collaboration with Hirschl that in cases of Graves' disease, following roentgen irradiation over the thyroid gland, the alimentary glycosuria disappeared. It then occurred to me to try roentgen irradiation of the thyroid in diabetics and I published a preliminary note on roentgen treatment in diabetics. In practice I had no success. The sugar tolerance of the diabetics did not increase. At that time, the relations between the pituitary and the thyroid were not yet known, neither the diabetogenic factor of the pituitary. So I irradiated the wrong gland. It should have been the pituitary, not the thyroid.

About the same time, I began roentgen treatment of hyperthyroidism. Since then, I have treated altogether about 300 cases of Graves' disease in Holzknecht's Laboratory (Allgemeines Krankenhaus in Vienna), in von Noorden's Clinic and in Wenckebach's Clinic in Vienna, as well as in my private practice, including this country.

My first statistical report,[12] based upon 40 cases, reads as follows: "The tremor and resulting weakness or psychic excitement disappeared in 90% of the cases, the heart symptoms (tachycardia) in 90%, the metabolic disturbance in 60%, the exophthalmos in 40% only." This was a relatively small number, but the results were obtained by irradiation of the goiter only. I want to stress this point! The same results were obtained in all my other cases treated by roentgen irradiation. Only 10 per cent of the cases showed no improvement or discontinued the treatment.

In 1909, shortly after the publication of the favorable results of the roentgen treatment, a great discussion developed in the Vienna Medical Society.[13] The surgeons were opposed to roentgen treatment of Basedow's disease; and, in particular, von Eiselsberg warned against the formation of adhesions which might prove a great obstacle to surgery should a resection of the goiter later become necessary. But in 1924 von Eiselberg himself declared that these feared adhesions were negligible. In the same debate, not only surgeons and radiologists but also neurologists, physiotherapists, climatologists and general practitioners participated, expressing their views on the treatment and etiology of exophthalmic goiter. Winternitz, a prominent physiotherapist, provoked the audience to laughter when he described a peculiar case, dating from an early period when nothing was known about the connection between the pituitary, the sex hormones and the thyroid gland.

I collected my material carefully and again published my experiences in 1921[14] and 1928.[15] In 1925, Dr. Hans Pollitzer, an assistant at Ortner's Clinic (Allegmeines Krankenhaus, Vienna), demonstrated what he termed cases of Basedow's disease of

hypophyseal origin. These cases were characterized by the absence of the thyroid gland, pronounced tremor and high grade increase of the metabolic rate. Iodine treatment had no effect. Pollitzer's important contribution was also based on a purely clinical observation. In 1926, Borak[2] for the first time published good results of roentgen treatment of the hypophysis, especially in post-climacteric women. This was a great step forward in roentgen therapy. However, this observation was not given a great deal of attention in America, although the good influence of roentgen irradiation of the pituitary in acromegaly, due to the decrease of excessive growth hormone of the pituitary's anterior lobe (first described by Béclère in 1909), was reviewed by Percival Bailey from Cushing's Clinic in 1925.

After 1932, when Loeb discovered a thyrotropic hormone in the hypophysis, the whole subject was put on a clear experimental basis. Still more interesting is the fact that exophthalmos can be induced more readily in a thyroidectomized animal than in an intact animal by injection of a hormone of the anterior lobe of the pituitary gland, which usually was identified with the thyrotropic hormone. In this respect Marine and Rosen's[7] (1933) and Smelser's experiments in 1937 on guinea pigs were decisive. One may term this hormone sympathico- or better adrenotropic (Collip) or exophthalmogenic. Thyrotropic would be the wrong term because this kind of exophthalmos has nothing in common with the thyroid or thyroxin. Incidentally, Raab and Hutton irradiate the adrenal region in essential hypertension. According to Mayo, the blood pressure in toxic adenoma is always increased and exophthalmos is rare, whereas in "true" Basedow's disease the blood pressure is not increased but exophthalmos is always present. It would be appropriate in every case of hyperthyroidism to irradiate the pituitary also, and to irradiate, as I have already said, the pituitary in diabetes on account of the increased diabetogenic factor. It is still unknown from which cells of the pituitary's anterior lobe this exophthalmogenic hormone is secreted, but its close relationship with the gonadotropic hormone, perhaps prolan B, appears probable.

One of my latest observations, made here in New York, was of a young woman, about twenty-eight, who suffered from Graves' disease and amenorrhea. Roentgen treatment of the thyroid improved her condition considerably, as regards the tremor, metabolic rate and tachycardia, but the exophthalmos did not show adequate improvement until the hypophysis was irradiated. Simultaneously with the disappearance of the exophthalmos regular menstruation was resumed.

Returning briefly to the history of roentgen treatment of hyperthyroidism, it is noteworthy that Portmann,[10] in "The Science of Radiology," writes:

> The beginning of roentgen therapy for exophthalmic goiter should be credited to Williams (1902). Carl Beck discussed it but advocated operation, leaving the wound open and applying irradiation postoperatively. It was not until several years later that favorable reports on the treatment of goiter began to appear in the literature in numbers. In 1904 Charles H. Mayo stated that he had observed the "sclerosing effect," which roentgen therapy produced in cervical lymph adenitis and concluded that the glandular activity of the thyroid might be reduced, and therefore had treated ten cases, making it a rule "in severe cases of exophthalmic goiter to treat by roentgen rays preoperatively for from two to six weeks." In 1906 Pfahler and Thrush[8] made a report of thirty-one cases collected from the literature and their own experience.

As mentioned before, my own experiences with this treatment commenced in 1908 and were neither pre- nor postoperative, but purely roentgen therapeutic applications.

Pfahler and Vastine,[9] reviewed more than 400 cases, of which 88 per cent improved. Soiland reported on 3,000 cases with about the same percentage of improvement.

A highly accurate contribution to our subject was published in 1929, by Solomon,[17] of Paris. He reviewed about 200 cases treated by roentgen radiation,stressed that operations have an average mortality of 7 per cent, and found that after roentgen treatment of his own 100 cases of Graves' disease, 70 per cent were cured, 27 per cent improved, and 3 per cent refractory. Solomon also pointed out that 25 per cent of cases of Graves' disease recur after operation.

Fig. 1. *A*, recurrent hyperthyroidism after operation. Exophthalmos increased. *B*, exophthalmos reduced after roentgen treatment of the thyroid. (From Solomon.[17])

In these recurrent cases also roentgen therapy achieves excellent results. Figure 1 concerns one such case. The exophthalmos was moderate after thyroidectomy, but the eyelids were very much more widened than before the operation and gave the patient the well known frightened look. Directly contradicting Dubois, Solomon declares that roentgen treatment is the method of choice. There is no mortality unless the heart has been severely damaged previously. It should be noted that Solomon irradiated the thyroid only, not the pituitary. This fact, together with my own observations, must lead to the conclusion that there are two kinds to exophthalmos, one pituitary in origin, and one thyroid in origin.

My own technique of application of the roentgen rays is based on the principle that Graves' hyperthyroid goiter should never be irradiated in one massive dose. The patient should always first be studied roentgenologically to ascertain whether a retrosternal goiter is present. Obviously a thoracic (retrosternal) goiter should also be irradiated. The average total dose for one series (three applications in one week) to the thyroid gland is 450 r, one from above and one from each side. The single dose is about 150 r. As a matter of routine, I always protect the larynx with a piece of lead rubber. I use about 160 kv. and a filter of 0.5 mm. Cu plus 1 mm. of aluminum. If this method of divided doses is used, the so-called early deep reaction, which may lead to a deep hyperemia and to initial increase in the thyroxin resorption,

never occurs. The first criterion of the effectiveness of the irradiation is the lowering of the basal metabolic rate. The increase in weight of the patient is usually apparent three weeks after the first series. If there is no considerable improvement after the first series, a second one and even a third series should be applied. In every case with marked exophthalmos the hypophysis should also be irradiated from the frontal and from both temporal sides, each dose being 200 r at 160 kv. with 0.5 mm. Cu filter.

When this method of small fractionated doses is used, the danger of myxedema described by Richardson in 4 irradiated cases of Graves' disease is avoided. Rother correctly points out that myxedema occurred also in cases of Graves' disease which were absolutely untreated. At any rate, I have put this risk in my material as negligible.

Comparing the thiouracil treatment with the roentgen treatment, we can see that both methods have nearly the same curative effect. The underlying biological process is obviously the same in both methods: a depression of the glandular function. No instance of a stimulating effect of roentgen rays has ever been proved. Roentgen rays suppress hyperactivity of cells in growth or function. Incidentally, it is interesting to note that if the whole body is subject to irradiation by roentgen rays or if any radioactive substance is injected, agranulocytosis may also result. But this danger does not exist with roentgen treatment which is localized to the thyroid or hypophysis. On the other hand, the thiouracil treatment does not require any apparatus. The danger of agranulocytic angina and other serious conditions can be avoided by lowering the maintenance dose. The so-called social indication exists in both methods.

At the Congress of Clinical Endocrinology (September, 1944) Grollman and Clifford suggested a combination of thiouracil therapy and roentgen irradiation as a substitute for the usual administration of iodine followed by thyroidectomy. They give 0.1 gm. of thiouracil six times a day for five days only. Considering that roentgen irradiation usually does not result in improvement before the lapse of some weeks, whereas thiouracil may cause the basal metabolic rate to begin to improve within only five days, thiouracil treatment followed by roentgen irradiation seems reasonably indicated.

In an article by Gargill and Lesses[5] published April 7, 1945, in which the danger of thiouracil in thyrotoxicosis was discussed, roentgen treatment is not even mentioned. I think it noteworthy that as late as July, 1945, in an article by Fishberg and Vorzimer[4] roentgen therapy of the thyroid and pituitary is not mentioned. It appears that at present there is only the choice between subtotal thyroidectomy, iodine therapy and thiouracil medication.

As roentgen rays suppress chiefly *hyperactivity* of cell growth and cell function, a normal thyroid or parathyroid is not affected by roentgen irradiation, but since a hyperactive and hypertrophic parathyroid probably will be affected by thiouracil or roentgen treatment, the disease termed osteitis fibrosa cystica appears to be a proper indication for an attempt to use thiouracil also. The drug thiouracil will perhaps act favorably in myelogenous leukemia, in generalized or non-generalized roentgen sensitive cancer or sarcoma. Radium and thorium X salts, which by their radioactivity are related to roentgen rays, are stored in the bone marrow and thiouracil is also stored there, although not, like radium salts, permanently, a fact which makes the injection of those radioactive salts so dangerous.

At the above mentioned Congress, Astwood stated that if thiouracil medication is stopped too early the metabolic rate rises again within five to forty-five days. However, when treatment with thiouracil was maintained for a period of from six to nine months, a continued remission occurred. But since a prolonged administration of the drug may result in agranulocyto-

sis and other toxic reactions, the combined thiouracil-roentgen treatment should, at present, be regarded as the method of choice. Since roentgen treatment gives permanent results it should never be omitted.

CONCLUSIONS

(1) The roentgen treatment of hyperthyroidism is a well proved method, giving at least the same good results as surgery and iodine treatment without any risk to the patient.

(2) The roentgen treatment of the pituitary gland should not be omitted, especially in cases with pronounced exophthalmos.

(3) Although thiouracil treatment is at present regarded as the method of choice, only competing with subtotal thyroidectomy or iodine treatment, the apparently forgotten roentgen treatment should be reinstated to its former important place.

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Twenty-eighth Annual Meeting: 1946, to be announced.

EDITORIAL

PNEUMOTHORAX IN YOUNG ADULT MALES

THE occurrence of spontaneous pneumothorax is not so infrequent as has been thought. Such reports as have appeared in the literature have dealt with small groups of cases or with those which have presented unusual features or complications. Most of the reports in which large numbers of cases are given have come from clinics or sanatoria dealing with tuberculous patients. Therefore it is of considerable interest to have a report on a large group of young adult males in which spontaneous pneumothorax occurred.

Such a study has recently been published by Lieutenant Colonel John E. Leach.[1] His report is based on 126 patients with 129 episodes of spontaneous pneumothorax observed among the military personnel in an Army Air Forces Training Command. Since all the military personnel had a roentgenogram of the chest made prior to entrance into the service and since many have roentgenograms made on entering active duty, the report dealing with such a group is of extreme interest and importance.

In the 126 male patients with spontaneous pneumothorax, one patient had one recurrence and one patient had two recurrences during the period covered by the survey. The ages of the men ranged from eighteen to forty-one years and averaged 24.8 years. It is of interest to note that there were no immediate fatalities in the group.

It has been taught and believed that the onset of spontaneous pneumothorax is usually sudden and is often associated with pronounced symptoms of dyspnea, pain in the chest, pallor and evidences of cardiovascular embarrassment. Contrary to this general belief and observation, in the patients reported in Leach's study the onset of the pneumothorax was gradual in an appreciable portion. In another appreciable portion the initial symptoms were either non-existent or quite mild in character, and the difference between those exhibiting no symptoms or only mild ones (63.5 per cent) and those exhibiting moderate and severe symptoms (36.5 per cent) is statistically significant. Leach suggests the possibility that the generally high state of physical fitness of the men in the Air Forces contributed to the mildness of the symptoms.

In the analysis of his cases he found no association between the severity of the reported symptoms at the onset of the attack and the degree of pulmonary collapse. In 76 of the total cases there was nothing in the past medical history that had any reasonable association with the onset of spontaneous pneumothorax. Eighteen of the patients had infections of the upper respiratory tract, many of which were mild. Although thirteen of the patients had an infection of the upper respiratory tract associated with cough, it is significant that in only one instance did the pneumothorax occur during a period of coughing.

It is of extreme significance that in the total 129 cases reported in Colonel Leach's survey, not one occurred during aerial flight. It is of considerable interest that in a higher percentage of the cases reported, the onset of pneumothorax was associated with a minimum of physical activity and in only a significantly lower percentage of cases was the onset associated with extreme physical activity.

This finding suggested to Leach two possible explanations: First, the amount of physical activity has little to do with the

[1] Leach, J. E. Penumothorax in young adult males. *Arch. Int. Med.*, 1945, *76*, 264–268.

onset of the average case of spontaneous pneumothorax, or second, the cause of the pneumothorax occurring at rest is quite different from the cause of that occurring during exercise. There was apparently in this group of cases no association between the amount of physical activity and either the symptoms or the degree of collapse of the lung at the onset.

In the group of cases reported, the valvular type of pneumothorax was an unusual occurrence.

It has been noted before, by Ornstein and Lercher,[2] that the more frequent occurrence of spontaneous pneumothorax is on the right side and in the survey by Leach this also held true; 59.8 per cent of the occurrences were on the right side. While this is significant, it was not apparent from this study why spontaneous pneumothorax occurs more frequently on the right side.

The estimation of the percentage of collapse in pneumothorax is difficult, as Leach says, because of the differences of methods among roentgenologists in estimating the percentage and also variations in the technique of making roentgenograms. However, in this series of cases, the patients had degrees of pulmonary collapse estimated at below 33 per cent.

The cause of the spontaneous pneumothorax was not determined for a great majority of the patients. Leach emphasizes the fact that subpleural emphysematous blebs or visceroparietal pleural adhesions could not be demonstrated on the roentgenograms but that these might have been present without their having been demonstrated.

Complications during the course of the pneumothorax were infrequent. The average length of hospitalization of the patients was 39.9 days, and 31.1 days was the average number required for the air to be reabsorbed.

It is of significance that of the 126 persons reported in this survey, 93 were retained in military service. It is also of significance that of the 41 patients who were flying personnel, the trained personnel and the student officers were either restored to flying directly after hospitalization or were suspended from flying up to twelve months and then restored, whereas the aviation cadets and aviation students, for the most part, were physically disqualified for further flying duty.

In this group, there were seven patients who gave a positive history of previous pneumothorax. These seven patients had a total of eleven previous episodes of pneumothorax and it is of interest to note that five of the seven patients had recurrences on the right side; it is also noteworthy that these recurrences were not associated with unusual physical activity.

It is extremely important that so large a group of healthy young adult males exhibiting spontaneous pneumothorax has been collected and analyzed. Contrary to what has been generally believed, the vast majority of these, namely in 85 out of 100 cases, the onset of the attack occurred when the patient was at rest or during only mild physical activity. The frequency of the occurrence of spontaneous pneumothorax on the right side is still not explained. Certain other facts of importance are gleaned from this report, namely that, on the average, the air can be expected to be absorbed in about twenty days in those patients who exhibit less than 50 per cent pulmonary collapse.

It is of importance to note that from an analysis of these cases Leach arrived at the conclusion that there is no demonstrable relation between flying and spontaneous pneumothorax.

[2] Ornstein, G. G., and Lercher, L. Spontaneous pneumothorax in apparently healthy individuals. *Quart. Bull. Sea View Hosp.*, 1942, 7, 149–187.

SOCIETY PROCEEDINGS, CORRESPONDENCE AND NEWS ITEMS

Items for this section solicited promptly after the events to which they refer.

MEETINGS OF ROENTGEN SOCIETIES*

United States of America

American Roentgen Ray Society
Secretary, Dr. H. Dabney Kerr, University Hospital, Iowa City, Iowa. Annual meeting: Netherland Plaza Hotel, Cincinnati, Ohio, Sept. 17–20, 1946.

American College of Radiology
Secretary, Mac F. Cahal, 540 N. Michigan Ave., Chicago.

Section on Radiology, American Medical Association
Secretary, Dr. U. V. Portmann, Cleveland Clinic, Cleveland, Ohio. Annual meeting: San Francisco, Calif., July 1–5, 1946.

Arkansas Radiological Society
Secretary, Dr. J. S. Wilson, Mack Wilson Hospital, Monticello, Ark. Meets every three months and also at time and place of State Medical Association.

Radiological Society of North America
Secretary, Dr. D. S. Childs, 607 Medical Arts Bldg., Syracuse, N. Y. Annual meeting: 1946, to be announced.

Radiological Section, Baltimore Medical Society
Secretary, Dr. Walter L. Kilby, Baltimore. Meets third Tuesday each month, September to May.

Section on Radiology, California Medical Association
Secretary, Dr. Gordon G. King, 3700 California St., San Francisco 18, Calif.

Radiological Section, Connecticut Medical Society
Secretary, Dr. Max Climan, 242 Trumbull St., Hartford, Conn. Meets bi-monthly on second Thursday, at place selected by Secretary. Annual meeting in May.

Section on Radiology, Illinois State Medical Society
Secretary, Dr. H. W. Ackemann, 321 W. State St., Rockford, Ill.

Radiological Section, Los Angeles County Medical Association
Secretary, Dr. Roy W. Johnson, 1407 S. Hope St., Los Angeles, Calif. Meets on second Wednesday of each month at the County Society Building.

Radiological Section, Southern Medical Association
Secretary, Dr. Roy G. Giles, Temple, Texas.

Brooklyn Roentgen Ray Society
Secretary, Dr. Leo Harrington, 880 Ocean Ave., Brooklyn, N.Y. Meets monthly on fourth Tuesday, October to April.

Buffalo Radiological Society
Secretary, Dr. Joseph S. Gian-Francheschi, 610 Niagara St., Buffalo, N. Y. Meets second Monday of each month except during summer months.

Chicago Roentgen Society
Secretary, Dr. F. H. Squire, 1754 W. Congress St., Chicago 12, Ill. Meets second Thursday of each month October to April inclusive at the Palmer House.

Cincinnati Radiological Society
Secretary, Dr. Samuel Brown, 707 Race St., Cincinnati, Ohio. Meets third Tuesday of each month, October to May, inclusive.

Cleveland Radiological Society
Secretary, Dr. Carroll C. Dundon, 2065 Adelbert Road, Cleveland 6, Ohio. Meetings at 6:30 P.M. on fourth Monday of each month from October to April.

Dallas-Fort Worth Roentgen Study Club
Secretary, Dr. X. R. Hyde, Medical Arts Bldg., Fort Worth, Texas. Meetings held in Dallas on odd months and in Fort Worth on even months, on third Monday, at 7:30 P.M.

Denver Radiological Club
Secretary, Dr. A. Page Jackson, Jr., 1612 Tremont Place, Denver, Colo. Meets third Friday of each month at Denver Athletic Club.

Detroit Roentgen Ray and Radium Society
Secretary, Dr. E. R. Witwer, Harper Hospital. Meets monthly on first Thursday from October to May, at Wayne County Medical Society Building.

Florida Radiological Society
Secretary, Dr. J. F. Pitman, Blanch Hotel Annex, Lake City, Fla. Meetings in May and November.

Georgia Radiological Society
Secretary, Dr. James J. Clark, 478 Peachtree St., Atlanta, Ga. Meets in November and at annual meeting of Medical Association of Georgia in the spring.

Radiological Society of Kansas City
Secretary, Dr. Arthur B. Smith, 800 Argyle Bldg., Kansas City, Mo. Meets third Thursday of each month.

Illinois Radiological Society
Secretary, Dr. Wm. DeHollander, St. John's Hospital, Springfield, Ill. Meets three times a year.

Indiana Roentgen Society
Secretary, Dr. H. C. Ochsner, Methodist Hospital, Indianapolis. Meets annually second Sunday in May.

Iowa X-Ray Club
Secretary, Dr. Arthur W. Erskine, 326 Higley Bldg., Cedar Rapids, Iowa. Luncheon and business meeting during annual session of Iowa State Medical Society. Special meetings by announcement.

Kentucky Radiological Society
Secretary, Dr. W. C. Martin, 321 W. Broadway, Louisville. Meets annually in Louisville on first Saturday in Apr.

Long Island Radiological Society
Secretary, Dr. Marcus Wiener, 1430-48th St., Brooklyn, N. Y. Meets Kings County Med. Soc. Bldg. monthly on fourth Thursday, October to May, 8:30 P.M.

Louisiana Radiological Society
Secretary, Dr. J. R. Anderson, 1130 Louisiana Ave., Shreveport. Meets annually during Louisiana State Medical Society Meeting.

Michigan Association of Roentgenologists
Secretary, Dr. E. M. Shebesta, 1429 David Whitney Bldg., Detroit. Three meetings a year, Fall, Winter, Spring.

Milwaukee Roentgen Ray Society
Secretary, Dr. C. A. H. Fortier, 231 W. Wisconsin Ave., Milwaukee, Wis. Meets monthly on second Monday at University Club.

Minnesota Radiological Society
Secretary, Dr. Annette T. Stenstrom, 1218 Medical Arts Bldg., Minneapolis, Minn. One meeting a year at time of Minnesota State Medical Association.

Nebraska Radiological Society
Secretary, Dr. D. A. Dowell, Medical Arts Bldg., Omaha, Nebr. Meets third Wednesday of each month, at 6 P.M. at either Omaha or Lincoln.

New England Roentgen Ray Society
Secretary, Dr. George Levene, Massachusetts Memorial Hospitals, Boston, Mass. Meets monthly on third Friday, Boston Medical Library.

New Hampshire Roentgen Ray Society
Secretary, Dr. Richard C. Batt, Berlin, N. H. Four meetings a year.

Radiological Society of New Jersey
Secretary, Dr. H. R. Brindle, 501 Grand Ave., Asbury Pk. Meets annually at time and place of State Medical Society. Mid-year meetings at place chosen by president.

New York Roentgen Society
Secretary, Dr. Ramsay Spillman, 115 East 61st St., New York City. Meets monthly on third Monday, New York Academy of Medicine, at 8:30 P.M.

North Carolina Roentgen Ray Society
Secretary, Dr. Major Fleming, Rocky Mount, N. C. An-

*** Secretaries of Societies not here listed are requested to send the necessary information to the Editor.**

nual meeting, Carolina Hotel, Pinehurst, N. C., May 1, 1946.

North Dakota Radiological Society
Secretary, Dr. L. A. Nash, St. John's Hospital, Fargo. Meetings held by announcement.

Central New York Roentgen Ray Society
Secretary, Dr. C. F. Potter, 820 S. Crouse Ave., Syracuse. Three meetings a year. January, May, November.

Ohio Radiological Society
Secretary, Dr. Henry Snow, 1061 Reibold Bldg., Dayton, Ohio. Meets during annual meeting of Ohio State Medical Association.

Pacific Roentgen Society
Secretary, Dr. L. H. Garland, 450 Sutter St., San Francisco, Calif. Meets annually, during meeting of California Medical Association.

Pennsylvania Radiological Society
Secretary, Dr. L. E. Wurster, 416 Pine St., Williamsport. Annual meeting, Berkshire Hotel, Reading, Pa., May 17–18, 1946.

Philadelphia Roentgen Ray Society
Secretary, Dr. C. L. Stewart, Jefferson Hospital, Meetings first Thursday of each month, October to May, at at 8:00 P.M., in Thomson Hall, College of Physicians, 21 S. 22d St.

Pittsburgh Roentgen Society
Secretary, Dr. L. M. J. Freedman, 4800 Friendship Ave. Meets 6:30 P.M. at The Ruskin on second Wednesday, each month, October to May inclusive.

Rochester Roentgen Ray Society, Rochester, N. Y.
Secretary, Dr. Murray P. George, Strong Memorial Hospital. Meets monthly on third Monday from October to May, inclusive, 8 P.M. at Strong Memorial Hospital.

Rocky Mountain Radiological Society
Secretary Dr. A. M. Popma, 220 N. First St., Boise, Idaho.

St. Louis Society of Radiologists
Secretary, Dr. Edwin C. Ernst, Beaumont Medical Building, St. Louis, Mo. Meets fourth Wednesday of each month, except June, July, August, and September, at a place designated by the president.

San Diego Roentgen Society
Secretary, Dr. Henry L. Jaffe, Naval Hospital, Balboa Park, San Diego, Calif. Meets monthly on first Wednesday at dinner.

San Francisco Radiological Society
Secretary, Dr. Joseph Levitin, 516 Sutter St., San Francisco 2, Calif. Meets monthly on the third Thursday at 7:45 P.M., first six months of the year at Lane Hall, Stanford University Hospital, and second six months at Toland Hall, University of California Hospital.

Shreveport Radiological Club
Secretary, Dr. R. W. Cooper, Charity Hospital, Shreveport, La. Meets monthly on third Wednesday, at 7:30 P.M., September to May inclusive.

South Carolina X-Ray Society
Secretary, Dr. T. A. Pitts, Baptist Hospital, Columbia, S. C. Meets in Charleston on first Thursday in November, also at the time and place of South Carolina State Medical Association.

Tennessee Radiological Society
Secretary, Dr. J. M. Frère, 707 Walnut St., Chattanooga, Tenn. Meets annually at the time and place of the Tennessee State Medical Association.

Texas Radiological Society
Secretary, Dr. R. P. O'Bannon, 650 Fifth Ave., Fort Worth 4, Texas. Next meeting, Dallas, Texas, Monday, January 14, 1946.

University of Michigan Department of Roentgenology Staff Meeting
Meets each Monday evening from September to June, at 7 P.M. at University Hospital.

University of Wisconsin Radiological Conference
Secretary, Dr. E. A. Pohle, 1300 University Ave., Madison, Wis. Meets every Thursday from 4:00–5:00 P.M., Room 301, Service Memorial Institute.

Virginia Radiological Society
Secretary, Dr. E. L. Flanagan, 116 E. Franklin St., Richmond, Va. Meets annually in October.

Washington State Radiological Society
Secretary, Dr. Thomas Carlile, 1115 Terry St., Seattle. Meets fourth Monday each month, October through May, College Club, Seattle.

X-ray Study Club of San Francisco
Secretary, Dr. J. M. Robinson, University of California Hospital. Meets monthly, third Thursday evening.

Cuba

Sociedad de Radiología y Fisioterapia de Cuba
President, Dr. J. Manuel Viamonte, Hospital Mercedes, Habana, Cuba. Meets monthly in Habana.

British Empire

British Institute of Radiology Incorporated with the Röntgen Society
Medical Members' meeting held monthly on third Friday at 2:30 P.M. and Ordinary Meeting at same time on following Saturday, October to May, 32 Welbeck St., London, W.1.

Section of Radiology of the Royal Society of Medicine (Confined to Medical Members)
Meets on the third Friday of each month at 4:45 P.M. at the Royal Society of Medicine 1, Wimpole St., London, W. 1.

Faculty of Radiologists
Secretary, Dr. M. H. Jupe, 32 Welbeck St., London, W. 1 England.

Section of Radiology and Medical Electricity, Australasian Medical Congress
Secretary, Dr H. M. Cutler, 139 Macquarie St., Sydney, New South Wales.

Radiological Section of the Victorian Branch of the British Medical Association
Secretary, Dr. Keith Hallam, St. George's Hospital, K.E.W., Melbourne, E. 4, Victoria, Australia. Meets monthly from March to November inclusive.

Canadian Association of Radiologists
Secretary, Dr. J. W. McKay, 1620 Cedar Ave., Montreal, P. Q.

Société Canadienne-Francaise d'Electrologie et de Radiologie Médicales
Secretary, Dr. Origène Dufresne, 4120 Ontario St., East Montreal, P. Q.

Section of Radiology, Canadian Medical Association
Secretary, Dr. C. M. Jones, Inglis St., Ext. Halifax, N. S.

Radiological Section, New Zealand British Medical Association
Secretary, Dr. Colin Anderson, Invercargill, New Zealand. Meets annually.

South America

Sociedad Argentina de Radiologia
Secretary, Dr. Guido Gotta, Buenos Aires, Argentina. Meetings are held monthly.

Sociedad Peruana de Radiologia
Secretary, Dr. Victor Giannoni, Apartado, 2306, Lima, Peru. Meetings held monthly except during January, February and March, at the Asociación Médica Peruana "Daniel A. Carrión, Villalta, 218, Lima.

Continental Europe

Sociedad Espanola de Radiologia y Electrologia
Secretary, Dr. J. Martin-Crespo, Fuencarral, 7. Madrid, Spain. Meets monthly in Madrid.

Société Suisse de Radiologie (Schweizerische Röntgen-Gesellschaft)
Secretary for French language, Dr. Babaiantz, Geneva.
Secretary for German language, Dr. Max Hopf, Effingerstrasse 49, Bern. Meets annually in different cities.

Societatea Romana de Radiologie si Electrologie
Secretary, Dr. Oscar Meller, Str. Banul Mărăcine, 30, S. I., Bucuresti, Roumania. Meets second Monday in every month with the exception of July and August.

All-Russian Roentgen Ray Association, Leningrad: USSR in the State Institute of Roentgenology and Radiology, 6 Roentgen St.
Secretaries, Drs. S. A. Reinberg and S. G. Simonson. Meets annually.

Leningrad Roentgen Ray Society
Secretaries, Drs. S. G. Simonson and G. A. Gusterin. Meets monthly, first Monday at 8 o'clock, State Institute of Roentgenology and Radiology, Leningrad.

Moscow Roentgen Ray Society
Secretaries, Drs. L. L. Holst, A. W. Ssamygin and S. T. Konobejevsky. Meets monthly, first Monday, 8 P.M.

Scandinavian Roentgen Societies
The Scandinavian roentgen societies have formed a joint association called the Northern Association for Medical Radiology, meeting every second year in the different countries belonging to the Association.

DEVICE FOR PREPARATION OF EYES FOR ROENTGENOSCOPY

To the Editor:

The ordinary so-called roentgenoscopy goggles have been used many years for preparation of the eyes for roentgenoscopy and protection against white light between cases examined roentgenoscopically. These goggles are cumbersome, uncomfortable and conspicuous. After experimenting for some months with a filter material covering only the area of my glasses, I have found that white light reaching the retina around the edge of the glasses does not affect greatly the sensitivity of the eye to the roentgenoscopic image. I submitted this idea to others, who also conducted experiments to determine if there were any considerable loss in efficiency in using a proper filter covering only the area of one's eye glasses. They reported that their findings were essentially the same as mine. Therefore, with the cooperation of the Picker X-ray Company, I had some clip-on frames with plastic filter made. I have used these lenses for several weeks and am pleased by the fact that I can drive my car to the office and be prepared for roentgenoscopic work in nearly as short a time as I could by wearing the old style mask type of goggles. Inasmuch as these clip-on filters are light, inconspicuous, and can be carried in the pocket, I believe that they are a great improvement over the previous devices available. For those who do not wear spectacles, plastic lenses can be mounted in ordinary spectacle frames.

Frank E. Wheatley, M.D.
129 West Elm St.,
Brockton, Massachusetts

NEED FOR RADIOLOGICAL LITERATURE IN BELGIUM

To the Editor:

We beg to inform you that our association created some years ago a Library especially devoted to the problems of cancer and which is at the disposal of the four Schools of Medicine of Belgium. As we were much deprived of any American medical or radiological literature during the war, we would be very glad if the members of your Society would send to the Library reprints or any published works dealing with the cancer problem. Please accept our best thanks in anticipation.

Ligue nationale belge contre le cancer
A. Vandenitte, Librarian
rue des Deux Eglises, 21
Bruxelles, Belgium

NORTH CAROLINA RADIOLOGICAL SOCIETY

The annual meeting of the North Carolina Radiological Society will be held at the Carolina Hotel, Pinehurst, North Carolina on Wednesday, May 1, 1946. The following program will be presented:

9:30 A.M. Business Session—Report of committees and election of officers

11:00 A.M. Film Reading Session—"Stump the Experts"
Fred Jenner Hodges, M.D., Professor of Roentgenology,
University of Michigan, Ann Arbor, Michigan
Experts: Robert J. Reeves, M.D., Professor of Radiology,
Duke University, Durham, N.C.
James P. Rousseau, M.D., Professor of Radiology,
Bowman-Gray Medical School, Winston-Salem, N.C.
Case Presentations by:
Allan Tuggle, M.D., Charlotte, N.C.
Graham Barefoot, M.D., Wilmington, N.C.
O. D. Baxter, M.D., Charlotte, N.C.
G. W. Murphy, M.D., Asheville, N.C.
B. E. Rhudy, M.D., Greensboro, N.C.

12:00 Noon to 2:00 P.M. Lunch—Carolina Hotel

2:00 P.M. CONTINUATION OF FILM READING SESSION:
EXPERTS: The Same
CASE PRESENTATIONS BY:
C. L. Gray, M.D., High Point, N.C.
J. E. Hemphill, M.D., Charlotte, N.C.
L. W. Oehlbeck, M.D., Morganton, N.C.
W. W. Vaughan, M.D., Durham, N.C.

3:00–4:00 P.M. "IT PAYS TO CATALOGUE X-RAY EXPERIENCES"
Fred Jenner Hodges, Professor of Roentgenology,
University of Michigan, Ann Arbor, Michigan

4:30 P.M. SOCIAL ACTIVITIES

DAVID ANDERSON-BERRY PRIZE

A David Anderson-Berry Silver-gilt Medal, together with a sum of money amounting to about £100, will be awarded in 1947 by the Royal Society of Edinburgh to the person, who, in the opinion of the Council, has recently produced the best work on the therapeutic effect of roentgen rays on human diseases.

Applications for this prize are invited. They may be based on both published and unpublished work and should be accompanied by copies of relevant papers.

Applications must be in the hands of the General Secretary, Royal Society of Edinburgh, 22 George Street, Edinburgh 2, by December 1, 1946.

NEW OFFICERS

The following are the recently elected officers of the American Roentgen Ray Society for the year 1945–1946: *President:* Dr. Ross Golden, New York, N. Y.; *President-Elect:* Dr. Raymond C. Beeler, Indianapolis, Ind.; *First Vice-President:* Dr. Francis F. Borzell, Philadelphia, Pa.; *Second Vice-President:* Dr. Ellis R. Bader, Cincinnati, Ohio; *Secretary:* Dr. H. Dabney Kerr (re-elected), Iowa City, Iowa; *Treasurer:* Dr. J. Bennett Edwards (re-elected), Leonia, N. J.

AMERICAN BOARD OF RADIOLOGY

The American Board of Radiology will conduct examinations at the Palmer House, Chicago, Illinois, on November 27 to December 1, 1946. This will be the only examination held during 1946. All those wishing to appear before the Board at this time *must* have their application on file by September 1, 1946.

B. R. KIRKLIN, Secretary
American Board of Radiology
Mayo Clinic, Rochester, Minn.

DEPARTMENT OF TECHNIQUE

Department Editor: Robert B. Taft, M.D., B.S., M.A., 103 Rutledge Ave. Charleston, S. C.

ELEMENTS OF ROENTGEN TECHNIQUE

THE UNIVERSAL DISTINCTOR OF HOLZKNECHT-INGBER IN THE EXAMINATION OF THE GASTROINTESTINAL TRACT*†

By EDMUNDO INGBER, M.D.
CORDOBA, ARGENTINA

IN THE early days of roentgen diagnosis of the gastrointestinal tract, Holzknecht devised two instruments, namely, the *spoon-shaped distinctor* for localization and controlled compression in a space 5 by 8 cm., and the *button distinctor* for the controlled compression and exact localization within an area of 1 to 2 cm. in diameter.

These are two wooden instruments carefully worked out by Holzknecht and adapted to all the demands of roentgen palpation which are encountered in its practical application every day; they have been substituted advantageously for the old method of palpation with the hand protected by the lead glove, which to be sure

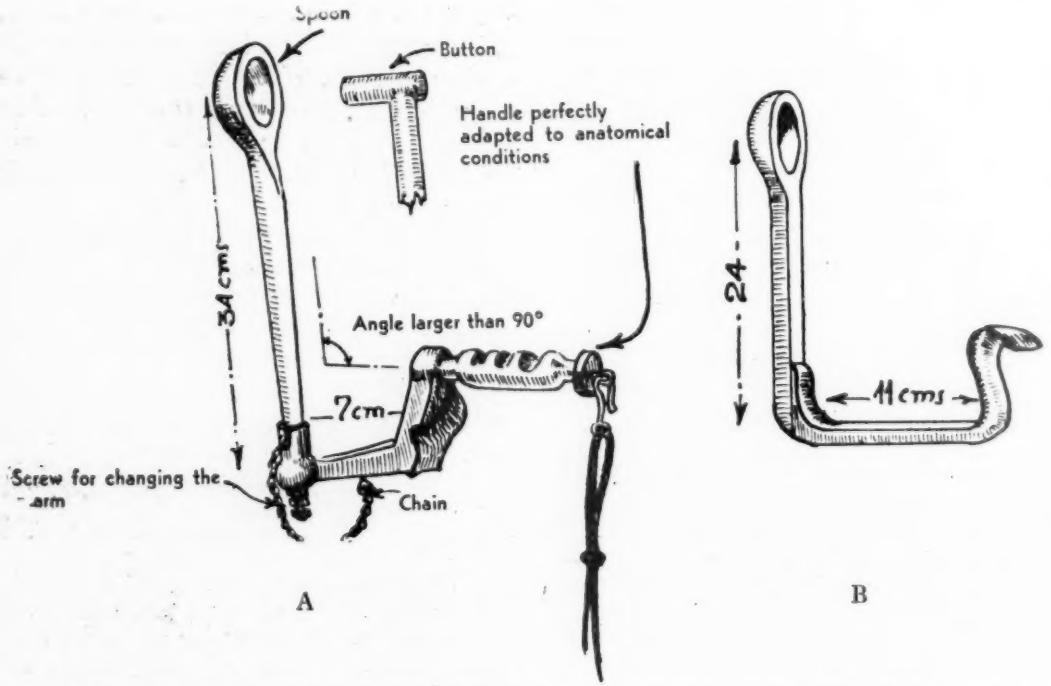

FIG. 1. *A*, universal spoon and button distinctor of Holzknecht-Ingber which fulfills all the requirements of roentgen palpation. *B*, imitation form of spoon distinctor derived from Holzknecht's which is of no practical use.

* Presented at the Discussions on Digestive Pathology, Italian Hospital of Santa Fe, August, 1942.
† Translated from the Spanish by Audrey G. Morgan, M.D., Medford, Oregon.

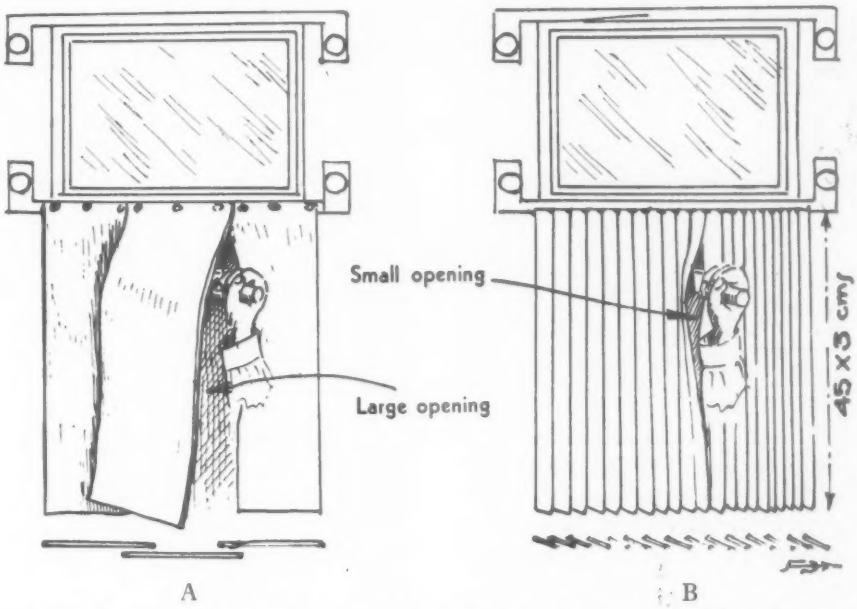

Fig. 2. Apron for protection against secondary radiation. *A*, current model; *B*, Ingber's model. Sketch of the roentgen field according to Ingber

Fig. 3. First phase. Simple diffuse localized compression showed the presence of a niche from ulcer of the lesser curvature of the stomach but failed to show the interruption of the fold mucosa at the base of the niche, an element in roentgen diagnosis which has pathognomonic value.

Fig. 4. Second phase. Controlled compression with Holzknecht's spoon made it possible to demonstrate not only the presence of the ulcer niche but also the lack of continuity of the gastric fold at its base.

Fig. 5. Third phase. Controlled compression with Holzknecht's button near the base of the niche makes better filling of it possible and shows its "penetrating" character.

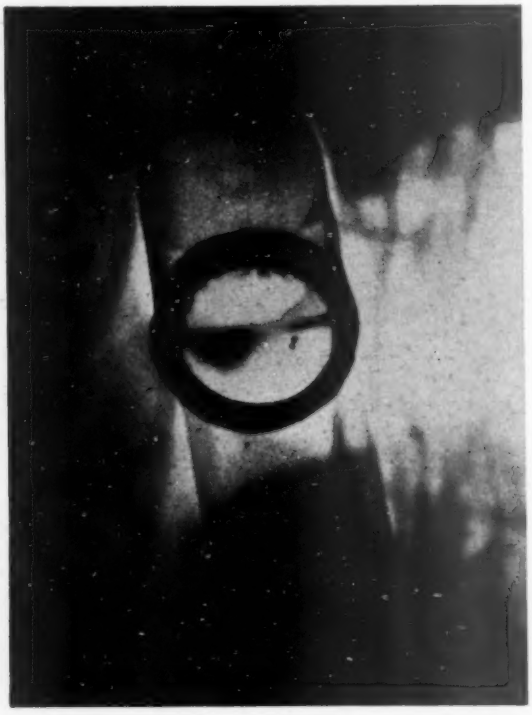

Fig. 6. Fourth phase. Controlled compression with Holzknecht's button in the act of focusing the niche with the greatest possible roentgen precision.

exercises pressure, but is quite useless because it covers the compressed zone and permits of observation only of the periphery and not of the center of the region under compression which is to be examined.

These two instruments are quite distinct from a poor imitation which is on sale in this country and which uses the name of Holzknecht illegally.

Many years of experience in the obscure field of gastrointestinal roentgen diagnosis has made us realize the inconvenience of interrupting the examination when it was necessary to use first one and then the other of the above-named instruments and the one which was not being used for the moment had to be laid down and the other felt for blindly.

The *universal distinctor of Holzknecht-Ingber,* which we brought from Europe, unites in *a single instrument* both these needs of roentgen diagnosis.*

Both instruments are suspended by small

* This device is being manufactured by Lutz and Ferrando of Argentina.

Fig. 7. *A* and *B*, imitation which is on sale in Argentina and which in reality does not serve the purposes which it claims. *1*, the universal distinctor of Holzknecht-Ingber unites in a single instrument the spoon and button for roentgen palpation. *2*, very light hollow sleeve of aluminum which, according to Holzknecht's original idea, perfectly meets the anatomical functional demands of the hand which is practicing palpation. *3*, only the left hand needs the protective glove. *4*, the right hand of the examiner, because of the construction of the instrument, is protected by the lead glass of the screen. *5*, palpation is begun with the spoon inserted. *6*, when the button distinctor is required, roentgenoscopy is interrupted for a moment, the spoon detached and the button inserted. *7*, between one examination and the next the instrument is hung around the neck of the examiner with the sleeve resting on his left forearm.

A
B
1
2
3
4
5
6
7

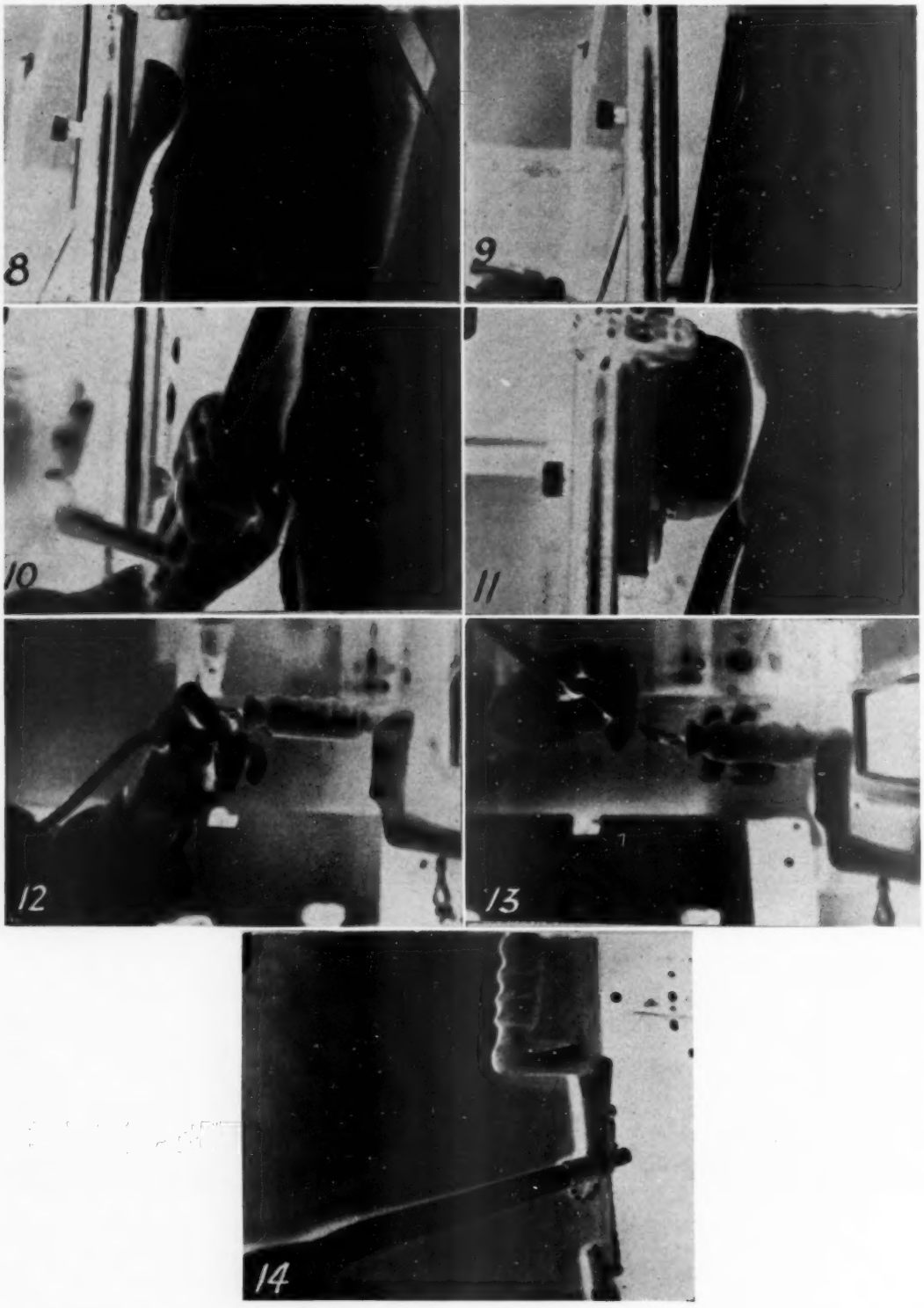

Fig. 8. *8*, controlled, local and circumscribed compression with the spoon. *9*, same with the button. *10*, the patient himself aids in keeping the distinctor in the required position. *11*, roentgenography with controlled, local and circumscribed compression. *12*, the cord is detached from the sleeve of the distinctor. *13*, the cord is reattached to the sleeve of the distinctor. *14*, suspended by the cord around the neck of the examiner at the proper time, the distinctor hangs free over the apron of the examiner, leaving both hands free.

chains from a very light hollow sleeve of aluminum, modeled faithfully on Holzknecht's original idea, which is perfectly adapted to the technical functional requirements of the hand which is practicing the roentgen palpation; either the one or the other can be inserted into the sleeve by means of a screw; the one which is not being used at the moment remains suspended from the sleeve.

Between one examination and the next the roentgen palpator can be hung around the neck of the examiner, the sleeve resting on his left forearm.

A glove for protection against the roentgen rays is necessary only for the examiner's left hand; the right hand, because of the characteristic construction of the instrument, is protected by the lead glass.

The palpation is begun first with the spoon-shaped distinctor; when the use of the button distinctor becomes necessary, roentgenoscopy is interrupted for a moment, the spoon unscrewed and the button inserted and then the examination, which has been interrupted only for the insignificant time required for this maneuver, is quickly continued.

Sometimes roentgenography of some diagnostic sign becomes necessary which can be accomplished only by the use of one of the palpators, with *controlled, local and circumscribed compression* at a given point of the organ under examination. In such a case the patient himself helps to keep the distinctor in the required position; he assumes control of the distinctor while roentgenoscopy is going on; then the red light is quickly lighted, the cord unhooked from the sleeve of the distinctor, the film introduced into the chassis above the distinctor and the patient freed from the compression, during which time the distinctor may hang free from the neck of the examiner, permitting him to use both hands.

In the survey of the subject which we have made this instrument seems to be very little used, but its use by us has proved invaluable on numerous occasions which have presented themselves in the course of years in the practice of roentgenology; it is easy to realize its value on the basis of the diagnostic discoveries made by it, many of which would otherwise have passed unobserved, with serious consequences in diagnosis.

9 de Julio 714,
Cordoba, Argentina.

IMPROVED TECHNIQUE FOR BRONCHOGRAMS*

By MAJOR WILLIAM A. ZAVOD
Medical Corps, Army of the United States

SINCE the introduction of iodized oil by Forestier in 1922, lipiodol has been widely used as a contrast medium for roentgenographic visualization of the bronchial tree. Various techniques for bronchograms are in use today. They range from instillation of the oil through a bronchoscope to mere dropping of the oil on the base of the tongue in the hope that it will seek out the pathologic condition and will be recorded on the roentgenogram. The object of a bronchogram is to demonstrate the presence or absence of a pathologic condition anywhere in the lungs, and therefore a bronchogram should produce visualization of all the major branches and their incident pathology in all the lobes of both lungs. It is the purpose of this paper to describe a technique which permits such visualization.

Objection might arise to the method on the ground that superimposition of the bronchial branches of the various lobes will result when the entire bronchial tree is outlined simultaneously, and thus obscure the pathologic condition in the individual lobes. However, four roentgenographic exposures taken in various positions, to be described below, will give perfect visualization of the state of the bronchi in each lobe of both lungs. There is no danger of critical loss of the physiological function of the lungs when only 20 cc. of lipiodol is used. This was investigated by the author spirometrically and will be the subject of another paper to be submitted for publication.

The method has the following advantages: (1) The entire bronchial tree of both lungs is outlined in one sitting. (2) It permits the study of topographical relationships between the various lobes in each lung. (3) Better roentgenograms result since they are not marred by residual lipiodol from previous instillations.

The technique described was employed in over 200 bronchograms. No failures were encountered; there were no complications or untoward effects.

The procedure will be described in detail since it is upon these details that the success of every bronchogram depends.

The patient is first examined to ascertain that he is not ill with an acute infection or any other disease which contraindicates the procedure. The ordinary chest roentgenogram, which is a prerequisite to a bronchogram, is studied in attempt to evaluate the presence of pathology. The patient is questioned about hypersensitivity to iodine and cocaine. The procedure of bronchography is explained to the patient and he is to be impressed that his cooperation is essential. No food or drink is to be taken by mouth for at least three hours prior to the examination. Non-fixed artificial dentures are to be removed. The teeth are brushed and the mouth and throat are rinsed with an alkaline antiseptic. A sedative of the barbiturate group, such as nembutal or seconal 0.05 to 0.1 gm., is given by mouth one-half hour prior to the procedure.

The following materials are to be prepared on a sterile tray: a French urinary catheter size 16, made of red rubber (radiopaque); a wire stylet having a laryngeal curve at one end; a De Vilbiss spray bottle; 10 cc. Luer lock syringe and laryngeal cannula; laryngeal mirror, head mirror, alcohol lamp; 2 per cent nupercaine and 4 per cent cocaine; 20 cc. lipiodol and some 4 by 4 inch gauze sponges. All boilable materials are to be sterilized, non-boilable objects are to be washed in 70 per cent alcohol.

The patient is seated in a chair, preferably with a head rest. The operator wearing gown and mask, seats himself in front of the patient at a slightly higher level so that he can look down into the patient's larynx. The larynx is examined by indirect laryn-

* From the Chest Section, Woodrow Wilson General Hospital, Staunton, Virginia.

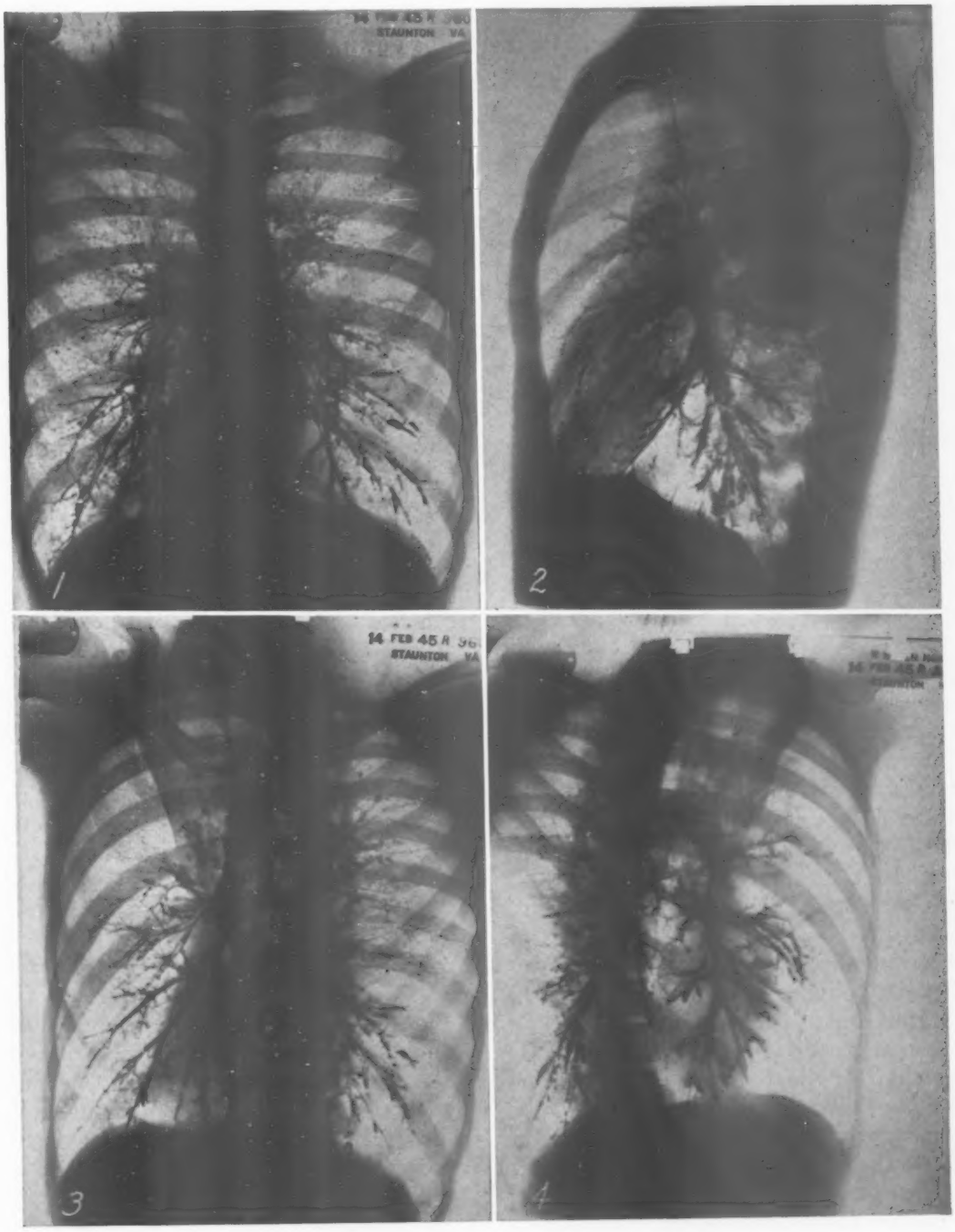

Fig. 1. Bronchogram taken in the dorsoventral position.
Fig. 2. Bronchogram taken in the right lateral position.
Fig. 3. Bronchogram taken in the left anterior oblique position.
Fig. 4. Bronchogram taken in the right anterior oblique position.

goscopy and any abnormalities are noted. The nasopharynx, including the base of the tongue and the soft palate, is anesthetized with 2 per cent nupercaine by the spray method, about five to eight applications are sufficient to anesthetize these structures.

The larynx, trachea and bronchi are anesthetized in the following manner: The cocaine is drawn up into the syringe and cannula. With the aid of the laryngeal mirror, a few drops of cocaine are placed on the free border of the epiglottis, the interarytenoid space and the true vocal cords. About 1 cc. of cocaine is instilled into the trachea; this will cover the carina and the main bronchi on the right. The patient is now instructed to lean to the left, and while the cannula is between the cords, another 1 cc. is instilled into the left branches. A total of 3 cc. of 4 per cent cocaine is ample for the average patient.

The stylet is introduced into the catheter which takes on the laryngeal curve of the former. Under indirect laryngoscopic vision the catheter and stylet are introduced between the cords and the catheter is fed into the trachea halfway off the stylet. The stylet is now removed from the catheter and a piece of folded gauze is placed between the patient's teeth with instruction to bite on it. This will permit anchoring of the catheter in place without obstructing its lumen.

The patient is now placed in the supine position on the level roentgenoscopic tilt-table, his head on a pillow. The head is turned to the left side and the chest is roentgenoscoped. The catheter is advanced to a position about 2 cm. above the carina. The syringe with 10 cc. of lipiodol is attached to the catheter by means of the cannula and the instillation of oil is begun under roentgenoscopic control. When the oil reaches the intubated end of the catheter, the patient is turned in the oblique position towards the left (right anterior oblique) and the oil will flow down into the left lower lobe. Next, the patient is turned still farther to the left until he is almost in the right lateral position; this will permit the oil to flow into the left upper lobe. It takes about 10 cc. of oil to fill the bronchi of the left lung. The syringe is refilled with another 10 cc. of oil, the patient's head is turned to the right; the left shoulder is raised and the patient is turned slightly to the right (left anterior oblique). As the oil runs down, it will fill the right upper lobe first; next, the lower lobe is filled and some of the oil will enter the middle lobe. After all the lipiodol is instilled, the catheter is removed. The patient is now told to turn in the prone position and one can visualize roentgenoscopically some of the oil running from the posterior bronchi to fill the anterior branches. Since the entire filling of the bronchi is done under roentgenoscopic control, any abnormalities are readily noted and serve as a check against the roentgenograms to be taken.

Careful roentgenoscopy is as important as the bronchogram. The dynamics of the bronchi are readily observed roentgenoscopically, also abnormalities like partial bronchial block or pooling of the oil can be easily seen, while they do not always show up on the bronchogram.

One must be cautious not to expose the patient to the roentgen ray for too long a period. A frequent momentary flash of the ray on the screen will permit visualization of the gradual filling of the bronchi without overheating the roentgen tube or causing injury to the patient.

With the patient in the erect posture, four roentgenographic exposures are made. A dorsoventral, a right anterior oblique, a left anterior oblique and a right or left lateral view, the latter depending upon the localization of the pathologic condition as it was observed under the roentgenoscope.

Figures 1, 2, 3 and 4 are reproductions of bronchograms made with above technique. Note the complete filling of the main branches of all lobes of both lungs; the demonstration of the pathologic condition and especially the localization of the disease in the posterior portion of the right upper lobe.

133 Archer Ave.,
Mt. Vernon, N. Y.

The author wishes to thank Major Donald Gordon, Chief Roentgenologist at the Woodrow Wilson General Hospital for the cooperation of his department.

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ABSTRACTS OF ROENTGEN AND RADIUM LITERATURE

ROENTGEN DIAGNOSIS

HEAD

Pereira da Silva, C. and Penha Godoy d'Alambert, J. Síndromo de hiperostóse frontal interna. (Syndrome of internal frontal hyperostosis.) *Arq. assist. psicopat. estad. São Paulo*, March–June, 1943, *8*, 101–141.

Internal frontal hyperostosis was first observed by the anatomist Morgagni in the autopsy of a woman who showed obesity and virilism. He wrote two papers on it in 1719 and 1761. The authors review the literature of the subject since that time, giving brief notes of the principal works on the subject.

Their own work consists of a discussion of 14 cases seen at the Juqueri Hospital in São Paulo, Brazil. Eight of the cases were purely clinical and in 6 anatomical as well as clinical examinations were made. Histories of all the cases are given and two tables showing the chief features of the cases in the two groups. The article is also profusely illustrated with photographs and roentgenograms of the patients. The disease is characterized, as its name indicates, by hyperostosis of the internal table of the frontal bone which sometimes extends to the parietal also. Moore classifies it into four groups which, however, are really only different stages of the process. The disease is probably due to a disturbance of calcium metabolism but it is hard to explain why the bone deposit is made only in the internal table of the frontal bone. Intracranial hypertension was found frequently. One patient had an eosinophilic hypophyseal adenoma, one a frontal meningioma involving most of the hyperostotic area and one had syphilis.

The great majority of the patients are women. In women who present obesity, headache, menstrual disturbances and hypercalcemia roentgen examination should be made for this disease. Four of these patients had epilepsy. As the material was from a hospital for mental diseases the significance of mental symptoms could not be judged.—*Audrey G. Morgan.*

Holvey, Ervin H., and Rosenthal, Louis M. Tomography in the region of the maxillary sinuses. *Radiology*, May, 1944, *42*, 458–465.

The object of this article is to compare the normal tomographic findings in the maxillary antra with the findings in disease. A series of tomograms were made at 0.5 cm. levels through the head of an adult cadaver in the anteroposterior projection. These are presented, together with tomograms taken in cases of infection of the sinuses and of carcinoma. Tomograms of infection show dense opacity of the antrum but the process does not involve the walls. This lack of involvement of the bony walls is most important in diagnosis. The antral cavities are symmetrical. The pathologic process generally extends to the adjacent ethmoid sinuses and there is practically always edema of the adjacent turbinates and the nasal mucosa

In cancer of the antrum the bony walls of the cavity are invaded, a differentiating sign from inflammation. The soft tissue shadow of the growing tumor extends beyond the bony walls and invades neighboring structures, such as the naris, orbit and mouth. The ethmoid sinuses are frequently invaded. The thin lower wall of the orbit explains the frequent extension to the orbit of cancer of the antrum.

Ordinary roentgenograms often fail to show the cancerous invasion of the bony walls of the antrum. Usually the patient does not come for medical advice until the cancer has destroyed the bony walls of the cavity and caused nasal obstruction, visual disturbance or pain by its expansion. If there are such symptoms and the ordinary roentgenograms suggest the possibility of cancer in this region a tomographic study should be made.—*Audrey G. Morgan.*

Maguire, Daniel L., Jr., and Kalayjian, Bernard S. Unusual stab wound. *Radiology*, July, 1944, *43*, 65–67.

The unusual feature of this case is that a part of a knife blade remained in the deep tissues of the face for four months without being discovered.

The patient was a colored man, twenty-seven years of age, who was stabbed in a quarrel in April, 1942. There was a small laceration about an inch long in the middle of the left zygoma. Probing did not show any foreign body and the lesion was cleansed and sutured; healing was by first intention and the patient was discharged five days later without pain, swelling, redness or fever. About four months later he returned to the hospital complaining of pain and stiffness in the jaw. It grew worse until he could open the jaw only about an inch and had to live on liquids entirely. No history of chills, fever, swelling, localized tenderness or drainage from the site of the injury.

Multiple roentgenograms of the skull and jaw showed a knife blade about 2½ inches long and ½ inch wide in the soft tissues of the left side of the face, extending medially and slightly downward and forward from a point just below and medial to the left zygomatic arch. Roentgenograms of the skull with the knife blade in situ are given.

The knife blade was removed. A small bent tip had broken off and remained in the wound. It was thought unwise to probe for it and it was not believed that it would cause any further trouble. The wound healed by first intention and in about a month the patient was able to open his jaw completely and eat all kinds of food. A year later he had had no further trouble.—*Audrey G. Morgan.*

NECK AND CHEST

Hankins, Walter D. Traumatic hernia of the lateral pharyngeal walls. *Radiology*, May, 1944, *42*, 499.

A case apparently unique in medical history is described. The patient was a trumpet player in the regimental band admitted to the Station Hospital at Fort Banks, Mass., for psychiatric examination. A bulge the size of an egg was seen in the right cervical region which appeared when the patient blew his trumpet. About six months before while playing his trumpet he felt something "give way" on the right side of his neck and ever since that time this bulge had appeared when he blew his trumpet. Roentgen examination showed that the lateral walls of the pharynx were herniated. The posterior wall was also weakened and bulged posteriorly upon the esophagus. The apices of the lungs rose above the clavicles and in the lateral view can be seen superimposed on the lower part of the trachea. Anteroposterior and lateral views of the case are given.—*Audrey G. Morgan.*

Lavner, Gerald, and Copleman, Benjamin. The antero-posterior lordotic projection in the roentgenographic examination of the lungs. *Radiology*, Aug., 1944, *43*, 135–141.

In some cases the usual roentgenographic examination of the chest does not show small lesions in the apices of the lungs. The authors describe the anteroposterior lordotic projection used in the demonstration of such lesions. The examination may be done rapidly with the use of only one 10×12 inch film. The patient faces the tube and with the knees slightly bent and the abdomen protruding in extreme lordosis leans backwards against the cassette holder. The central ray is directed horizontally. The technical factors used are such that the exposure is twice that for the routine posteroanterior projection at 6 feet; or the same factors are used as in the ordinary examination and the distance decreased to 4 feet.

This position causes the clavicles to be projected upwards while the anterior portions of the ribs become practically horizontal. This projection has proved most useful in cases in which there is only a suspicion of a shadow behind the clavicles.

Photographs of a patient in position for examination and roentgenograms of illustrative cases are given.—*Audrey G. Morgan.*

Zanca, Peter, and Herpel, Frederick K. A statistical analysis of 100,000 examinations of the chest by the photoroentgen method. *Radiology*, Aug., 1944, *43*, 122–128.

Tables are given showing the results of routine examination of the chest by the photoroentgen method of 100,000 selectees reporting to the Armed Forces Induction Station at Fort Bragg, North Carolina. Heretofore routine chest examinations have been made with stereoscopic 14×17 inch films but the authors find that the photoroentgen method with 4×10 inch films is better. It is much cheaper and the films can be read and interpreted much more rapidly. Besides, the sharpness and definition of the image is greater on the smaller films. Superior films are produced by the use of a Lysholm grid in front of the intensifying screen.

The rejection rate for pulmonary tuberculosis

in this series of cases was 4.91 per thousand. This included all types of tuberculosis from advanced to apparently arrested cases. This is a very low rate as compared with that in the country as a whole which for the period from November, 1940 to December, 1941 was 11.06 per thousand. This low rate is doubtless due in part to the splendid antituberculosis campaign that has been carried on in North Carolina for the past twenty-five years, in part to the fact that known cases of tuberculosis were screened out by the local boards and in part to the fact that most of these draftees were from rural regions.—*Audrey G. Morgan.*

Waring, James J., and Schmidt, Ernst A. Esophagocecal fistula diagnosed roentgenologically. *Radiology*, July, 1944, *43*, 59–62.

As no similar case is known in the literature the authors report a case of stricture of the esophagus in a woman of forty-five caused by swallowing lye. She came to the Colorado General Hospital March 4, 1943, complaining of loss of weight and strength and inability to retain food. She said she did not always regurgitate her food, which was entirely liquid, and she was sure some of it passed into her stomach. In about three-quarters of an hour she had several loose stools which resembled the food just swallowed. There were none of the usual eye and mouth signs of vitamin deficiency. She had pain in the right loin and walked with a distinct limp, which suggested iliopsoas spasm. Apparently successful dilatation of the esophagus had been done but she did not gain in weight and this fact, in conjunction with the flushing of the bowels and pain in the loin, suggested esophageal fistula.

The first roentgen examination March 11, 1943, showed a fistulous tract extending from the esophagus into the abdomen and a further examination in April showed that the fistula extended into the cecum. It was surrounded by a mass of gristly white tissue. There had been no marked symptoms to show when the perforation occurred. A gastrostomy was performed on April 30 and nine days later death occurred from peritonitis and bronchopneumonia; death was entirely independent of the esophageal and cecal lesions. An appendectomy had been performed recently and it is not known whether it had anything to do with the perforation of the fistula into the cecum.—*Audrey G. Morgan.*

Peterson, Vernon L. Fungus disease of the chest. *Radiology*, July, 1944, *43*, 14–20.

The author discusses a group of lung infections caused by *Coccidioides*, *Actinomyces*, *Aspergillus*, *Monilia albicans*, *Torula* and *Blastomyces*. In about one-fourth of these cases there was fungus infection elsewhere in the body and this is an aid in the differential diagnosis of the lung lesions. Both the clinical and roentgen findings are similar to those of tuberculosis so that differentiation is difficult. However, though a diagnosis cannot be based on a single roentgen examination there are certain features which appear on repeated examinations which aid in diagnosis if the roentgenologist is familiar with them. These findings are briefly discussed for the different groups of fungus infection and illustrated with roentgenograms. In lesions that look like tuberculosis but in which no tubercle bacilli can be found, a very careful search for fungus infection should be made. If no fungi can be isolated a therapeutic test with iodides may be made; a positive response indicates fungus infection.

All of the cases of coccidioidomycosis were from the southwestern United States, most of them from California. Several had a history of a fever resembling influenza that was doubtless "valley fever." There was little clinical evidence of disease in any of them.

Doubtless many cases of fungus infection will be seen as the men return from the Army camps. It is important that these lesions be recognized and differentiated from tuberculosis or other more serious diseases as the course of the fungus infections is usually benign and it will not be necessary for the patients to give up their work.—*Audrey G. Morgan.*

Johnston, Wayne A., and Heydemann, Julius. Clinical and radiological studies in pulmonary mycosis. *Radiology*, July, 1944, *43*, 1–13.

Only a small number of yeast fungi are pathological to animals and man. Their classification is extremely difficult and the authors think it better to consider diseases caused by them from the point of view of their virulence rather than from that of the species of fungus causing them. Susceptibility seems to be influenced by whether the region is infected or non-infected rather than by any personal characteristics of the patient, such as age, sex

or occupation, though blastomycosis seems to occur more frequently in men who handle cattle.

The symptoms do not differ strikingly from those of other lung infections. The clinician will note that there is some type of lung disease, the roentgenologist can learn its extent and distribution but the final diagnosis must be made by demonstration of the fungi in sputum cultures. At present it is often not recognized until a late or terminal condition has developed. The authors urge research to find a means of differential diagnosis of these infections early in their course.

Roentgen differentiation of fungus infection from tuberculosis is not reliable. The two diseases may coexist and the mere finding of yeast fungi does not prove that the patient does not have tuberculosis. This should be borne in mind in treatment.

The best treatment for mycosis of the lungs is iodides and roentgen irradiation. In moniliasis and blastomycosis it may be necessary to desensitize the patient to the yeasts before he is given iodides. This is done by giving Lucas vaccine, 0.1 cc. twice a day, increasing to 0.8 cc. for a total of eighteen injections.

Eight cases are reported in detail and illustrated with roentgenograms and photomicrographs of lung tissue.—*Audrey G. Morgan.*

Levene, George, and Sterman, Ida A. Roentgen study of primary atypical virus pneumonia. *Radiology*, May, 1944, *42*, 446–457.

Small epidemics of virus pneumonia have been prevalent in this country since 1935. It is probably caused by a filtrable virus. The disease has not been transmitted to animals.

The authors made a roentgen study of 100 consecutive cases in the Department of Radiology of the Massachusetts General Hospital. Roentgenograms of the various stages of the disease are presented. The first lesion visible roentgenologically is a severe tracheobronchitis. The process is destructive and quite different from the inflammatory exudates seen in pneumococcic pneumonia. In the comparatively few autopsied cases the lungs were red and edematous. There were small areas of focal or lobular atelectasis and areas of emphysema. The emphysema prevented total lobar atelectasis so that consolidation was generally not uniform. During the course of the disease the roentgen appearance may vary greatly and may simulate tuberculosis, lobar pneumonia, bronchopneumonia, abscess, bronchiectasis, metastatic carcinoma or pulmonary edema. It may be necessary to base the diagnosis on the history, clinical and laboratory findings and serial chest roentgenograms.

Resolution progresses from the periphery toward the center, unlike that of pneumococcic pneumonia. The average duration of symptoms on admission in these cases was seven days. There were visible roentgen changes at this time. It has been stated that the first roentgen changes appear on the fourth day. In this series the average time for the beginning of resolution was on the seventeenth day and that for return to normal the twenty-fifth day. Roentgen signs may persist long after clinical cure, suggesting the possibility of chronic complications, particularly bronchiectasis. It is therefore advisable to take a roentgenogram on the day of discharge and another some time later if there is any indication for it.—*Audrey G. Morgan.*

Ehrlich, David E. Aortic arch and cardiac mensuration. *Radiology*, April, 1944, *42*, 382–383.

The author describes a simple method of measuring the heart and aortic arch which he has found satisfactory in over twenty years' experience.

A routine posteroanterior roentgenogram is taken at 6 feet distance with the patient standing facing the film and in full inspiration. After dark-room processing a midline is drawn by dropping a plumb line through the posterior spinous process of the mid-cervical vertebrae. Next a horizontal line is drawn at the level of the cardiophrenic angle. The transverse diameter of the chest is measured along this from the inner rib borders on each side. The distance from the midline to the right and left borders of the heart is then measured. The sum of these two distances gives the transverse diameter of the heart. The ratio of this to the transverse diameter of the chest is figured out. The measurement of the aortic arch is obtained by measuring the greatest distance from the midline to the left, which roughly approximates a 10:1 ratio to the transverse diameter of the chest. This eliminates the need of hunting for the right margin of the aortic arch which is often hidden behind the sternum.—*Audrey G. Morgan.*

Deweese, E. R., and Howard, John C., Jr. Congenital absence of a lung diagnosed before death. *Radiology*, April, 1944, *42*, 389–391.

Congenital absence of the lung is considered rare. Only 38 authenticated cases have been reported since the first one in 1787. Only 3 of these cases were diagnosed before death. One lung functioning normally is sufficient for life as shown by the fact that 11 of these patients were over 20 years of age and one was 65. The increased use of routine chest plates in the armed services will without doubt reveal many more of these cases.

One is described in a boy 6 months of age. This is the second case seen in the Children's Mercy Hospital, Kansas City, Mo. in the past 6 years. Both were diagnosed during life. This patient was admitted with a diagnosis of acute bronchitis, pharyngitis and atelectasis of the right upper lobe. Roentgen examination showed a dense homogeneous opacity over the entire right lung field with great displacement of the mediastinal structures to the right. The heart lay entirely to the right side of the vertebral column. There was over-aeration of the left lung which extended across the right side of the chest. On bronchoscopic examination no opening of the right main stem bronchus could be found. Obviously no air was entering the right lung. A diagnosis of agenesia of the right lung was made. The child died three days later and autopsy confirmed the diagnosis. It should be possible to make a diagnosis of this condition during life by the use of roentgen examination, lipiodol injection and bronchoscopy.—*Audrey G. Morgan.*

Stein, George H., and Kresky, Philip J. Comparative roentgen study of primary atypical and bacterial pneumonia. *Radiology*, May, 1944, *42*, 435–445.

Various writers on the subject have attempted to describe roentgen pictures of atypical and bacterial pneumonias which would serve to differentiate the two types of disease. The authors made a study of 2,062 cases of pneumonia seen at the Regional Station Hospital in Sioux Falls; 950 were bacterial pneumonias and 1,112 were primary atypical pneumonias. For purposes of comparison they have selected 19 cases of the two types and give clinical histories and roentgenograms. From a careful study of these it is evident that it is impossible to make a diagnosis of the etiology of a given case of pneumonia from the roentgenogram alone. Cases of primary atypical pneumonia may show a roentgen appearance that cannot be distinguished from that of pneumococcic pneumonia, especially in the early and resolving stages of the latter. Contrary to most of the descriptions in the literature, they saw many cases of atypical pneumonia which did not originate in the hilar regions and extend outward but occurred as circumscribed foci in the periphery of the lung. They also saw primary atypical pneumonias which occurred in the upper lobes with roentgen findings resembling those of tuberculosis.

Any accurate differentiation between the two types of pneumonia must take into consideration the clinical and laboratory findings as well as the roentgen appearance.—*Audrey G. Morgan.*

Lewis, Elbert K., and Lusk, Frank B. Roentgen diagnosis of primary atypical pneumonia. *Radiology*, May, 1944, *42*, 425–434.

Atypical pneumonia is a virus disease, which may be of known etiology, as influenza A or B or psittacosis, or of unknown cause. The author discusses 6,000 cases of acute epidemic infection of the respiratory tract seen at the Station Hospital, Fort Custer, Mich. Of 500 such patients studied in detail about 25 per cent showed roentgen evidence of atypical pneumonia.

Atypical pneumonia shows four phases. The first or bronchitic phase is characterized by increased size and density of one or both hilar shadows and prominence of the truncal shadows extending from the hila into the lower lobes. This phase must be differentiated from acute and chronic bronchitis and passive congestion and enlargement of the hilar nodes from any cause. The second or peribronchitic phase shows increased prominence of the truncal markings extending downward into the lower lobes and outward into the lung parenchyma. This is the phase most likely to be confused with bronchiectasis. In the third or alveolar phase the lesion varies in size, location, shape and density. Usually it extends from the hilum outward and downward into the lower lobes. The roentgen shadow varies from the size of a millet seed to involvement of the greater part

of a lobe. Because of the great variability in the shadow this phase must be differentiated from many other lung conditions, such as the bacterial pneumonias, especially the lobar type, tuberculosis, atelectasis, pulmonary abscess, encapsulated fluid, tumors and rickettsial and fungus infections. The fourth or bronchoalveolar phase shows irregular, soft, patchy mottled areas of increased density in the lung parenchyma. It must be differentiated from bacterial bronchopneumonia, the rickettsial and fungus infections, tularemia and measles pneunonias and occasionally infected bronchiectasis.

Roentgenograms of these different phases and photomicrographs of the histopathological findings are given. The roentgen appearance alone, however, is not enough for differentiation but the clinical and laboratory findings must be taken into consideration.—*Audrey G. Morgan.*

Lowry, Thomas, and Rigler, Leo G. Adenoma of the bronchus: a clinical and roentgenologic study with a report of seven cases. *Radiology*, Sept., 1944, *43*, 213–229.

Malignant tumors of the bronchi are very frequent; benign bronchial tumors are much less common but not rare. About 80 per cent of the group of benign growths are adenomata. It is important to differentiate these from carcinoma as they require less radical treatment. While adenoma is classified as a benign tumor it is locally malignant in the sense that it invades beyond the wall of the bronchus and there is often an extrabronchial mass. This is due to the fact that this form of tumor probably originates from the duct epithelium of the bronchial mucous glands and the mucous ducts penetrate the cartilaginous rings. But it does not produce malignant metastases and in this sense may be said to be clinically benign.

Differentiating signs between adenoma and carcinoma are that 80 per cent of adenomata occur in patients less than forty years of age while 90 per cent of carcinomata occur in subjects over forty; 70 per cent of adenomata are in females while 85 per cent of carcinomata are in males; on bronchoscopy the adenoma is a smooth, pink, oval or lobulated mass, often pedunculated; the bronchus is not fixed. Troublesome bleeding is produced on biopsy. Carcinoma is irregular, yellowish or gray, often ulcerated; the bronchus is infiltrated and fixed. On biopsy there is not profuse hemorrhage. In adenoma bronchiectasis is frequent, due to the slow course of the disease, while in carcinoma it is rare as the disease is rapidly progressive. Hemoptysis is often profuse in adenoma, beginning and ending abruptly, while in carcinoma it is usually only streaking and often continuous.

If the clinician has bronchial adenoma in mind a diagnosis can generally be made by roentgen examination and bronchoscopy. A patient with a chronic productive cough, recurrent hemoptysis and fibrocavernous destruction of one upper lobe, whose sputum is negative for tubercle bacilli should be examined for bronchial adenoma by all possible means including body section roentgenography, which often permits of direct visualization of the tumor as a rounded, sharply defined dense shadow in contrast with the air in the bronchus which surrounds it.

Local bronchoscopic removal may be used in the treatment of these tumors in young patients whose lung shows little damage and who can be closely followed up. Irradiation has not proved of great value and there is a risk of death from hemorrhage due to deep necrosis of the bronchial wall eroding large vessels. Resection of the lung is indicated in a large majority of the cases but the advantages to be gained must be weighed carefully as compared with the very considerable danger of the operation. Seven cases are reported and illustrated with roentgenograms.—*Audrey G. Morgan.*

Kraft, Ernest. Lung abscess secondary to stenosing bronchiogenic carcinoma. *Radiology*, July, 1944, *43*, 39–47.

Pulmonary carcinoma now causes 10 per cent of all carcinoma deaths. In addition to an actual increase there is an apparent increase due to more thorough roentgen examination and greater familiarity with the picture. It is believed that as many as 90 per cent of cases could be recognized with proper examination and two-thirds of cases from roentgenograms alone. There are two reasons why many cases are still unrecognized: (1) when the lung tumor remains asymptomatic distant metastases may be mistaken for the primary tumor; (2) stenosing bronchiogenic carcinoma, which is the most common form, is usually masked by infections of the surrounding lung and pleura.

Stenosing bronchiogenic carcnioma can be cured if diagnosed early. Histologically it is a

squamous-cell growth and is much less malignant than the adenocarcinomas and small-cell sarcomas which develop outside the bronchi. Death is usually caused not by the tumor but by secondary changes in the lung. When the obstruction of the bronchus remains complete secretion accumulates on the distal side of it and causes bronchiectasis; secondary infection then causes chronic pneumonia, lung abscesses or pleurisy. The tumor may become so necrotic as a result of these secondary changes that it practically disappears and can only be recognized on careful microscopic study. It is very important for roentgenologists to know of these abscesses secondary to stenosing bronchiogenic carcinoma for if diagnosis is made promptly radical surgery may save the patient's life.

Three typical cases of lung abscess secondary to stenosing bronchiogenic carcinoma are described and illustrated with roentgenograms. —*Audrey G. Morgan.*

Rowland, Driver. Cardiac aneurysm; Report of a case with correlation of clinical, radiological and electrocardiographic findings. *Ann. Int. Med.*, August, 1943, *19*, 349–356.

A case is reported and a review of the literature is given. About 85 per cent of ventricular aneurysms are said to follow cardiac infarction subsequent to the occlusion of a coronary artery. The balance is made up of miscellaneous causes such as syphilis of the myocardium or is of mycotic, traumatic, congenital and traumatic origin. Subsequent to the occlusion of a coronary vessel there appears necrosis of the myocardium supplied by this vessel with replacement fibrosis. This weakened area then stretches with the production of a large or small aneurysmal dilatation, depending on the size of the area involved. This may be saccular in outline communicating with the ventricular cavity by a neck or more often a bulge or outpouching, not sharply delineated, of the ventricle. An aneurysm may be located in any part of the left ventricle. Aneurysms of the right ventricle are rare but the most common site is the anterior wall involving the apex of the left border just above the apex.

Clinically there is nearly always a past history of coronary occlusion. An enlarged heart is characteristic but this alone is without significance unless it occurs in a patient who was previously known to have no cardiac condition that would explain this enlargement. Pulsatory phenomena have been of great diagnostic significance. Roentgenography, more especially roentgenoscopy, offers the best means of accurately diagnosing cardiac aneurysm. The following roentgenographic signs are said to be of diagnostic significance: (1) enlargement of the left ventricle with deformity of its contour; (2) a localized protuberance inseparable from the heart shadow on rotation of the patient; (3) abnormal or absent pulsations of the aneursymal zone; (4) evidence of adhesions between the heart and the chest wall; (5) calcification of the wall of the sac or contained clot. There are three significant changes to be noted upon roentgenoscopy: (1) a diminished or total lack of pulsation in the region of this bulge; (2) a paradoxical pulsation in the region of the supposed aneurysm, i.e. a systolic expansion of this area; (3) calcification of the pericardium or wall of the aneurysm.

In view of the rarity of occurrence of right axis deviation in cases with hypertensive or arteriosclerotic heart disease and of its frequency (40 per cent of cases) in cardiac aneurysm, it is believed that this type of electrocardiogram is very suggestive of a cardiac aneurysm and when it occurs unexpectedly in a case of otherwise unexplainable left ventricular enlargement the possibility of this diagnosis should be brought to mind.—*J. J. McCort.*

Miller, Henry. Spontaneous mediastinal emphysema. *Ann. Int. Med.*, Dec., 1944, *21*, 998–1010.

A short résumé of the causes of mediastinal emphysema from the literature is given. Certain characteristic physical findings indicative of pneumomediastinum are said to have been described by Muller in 1888. There are: (1) the presence over the precordium of bubbling crepitation synchronous with the heart beats, (2) the disappearance of cardiac dullness, (3) the appearance of subcutaneous emphysema. The diagnosis in most cases is not difficult when the distinctive sounds heard over the heart and the roentgenographic evidence of air in the mediastinum are present. In this paper 4 additional cases of spontaneous mediastinal emphysema are added to the literature of those previously reported. In each case the diagnosis was made by the detection of the typical sounds over the heart. The diagnosis was confirmed by roentgenographic study. It is pointed out that the heart sounds show great variation in in-

tensity and quality during the course of the condition. They may be detected after the appearance of spontaneous pneumothorax and may last for several weeks.

The experimental studies made by Macklin (*Arch. Int. Med.*, 1939, *64*, 913–926) on the pathologic physiology are quoted in detail. By artificially increasing the intrapulmonary pressure in the lobe of the lung of cats and other animals he was able to demonstrate that the air enters the perivascular sheath of the finer branches of the pulmonary vessel, presumably through the numerous minute ruptures in the walls of the alveoli. As the increased pulmonary pressure continues, the small bubbles of air coalesce into large ones as they move towards the roots of the lungs through the artificially produced channels in the vascular sheaths. At the root of the lung the air bubbles may merge into large blebs which can impede the pulmonary circulation. Further leakage causes these blebs to break through into the mediastinum. At times the air in the perivascular sheaths may extend into the adjoining connective tissue and dissect a pathway towards the pleura where it forms a subpleural bleb, particularly in the region of the root of the lung. Rupture of this bleb may occasionally produce a pneumothorax.

The paths of extension of air in the mediastinum have also been studied. The air tends to follow with predilection the fascial planes, particularly the sheaths surrounding blood vessels. It may spread upward into the root of the neck, the face, axilla, anterior chest wall, and arms. It is possible for it to dissect up along the sides of the trachea to the floor of the mouth extending under the base of the tongue which becomes elevated. It may extend forward between the parietal pleura and pericardium to appear as blebs overlying the heart, laterally into the opposite lung and downward into the retroperitoneal space where it may outline the kidneys, ureters and renal vessels.

Roentgenographic demonstration of air in the mediastinum is diagnostic. In the anteroposterior view only the outlined pockets of air may be seen, so that lateral and oblique views should also be taken. In these views air may be visible between the heart and the posterior chest wall or in the posterior mediastinum. In rare cases when the air does not extend forward around the heart the characteristic auscultatory signs may be absent and the roentgenographic evidence of air in the mediastinum may be decisive. Air may also be detected in the subcutaneous tissues of the neck and in the retroperitoneum.

An additional case is reported in which pneumomediastinum followed postoperative massive atelectasis of the right lung. In this case it was believed to be due to over-distention of the left lung. The alveolar ectasia in the left lung permitted the air to escape into the perivascular sheaths and lead to mediastinal and subcutaneous emphysema.—*J. J. McCort.*

Robbins, Laurence L. The roentgenologic features of mediastinal tumors. *Radiology*, Aug., 1944, *43*, 115–121.

From 1938 through 1942, forty-four cases of proved mediastinal tumor were seen at the Massachusetts General Hospital. They are discussed with a view to determining whether they can be classified by roentgen examination before operation. No absolutely diagnostic signs of the different types were found but certain roentgen signs aid in differentiation.

Among the chief types the bronchiogenic cysts show a smooth round or ovoid shadow anywhere in the mediastinum, with no evidence of bone erosion or calcification. They may be attached to the trachea but other pathologic masses may also. Unless the cyst becomes infected it is usually found incidentally.

All of the dermoid cysts were in the anterior mediastinum. The outline was more irregular than that of the bronchiogenic cysts. Three of the 7 cases showed calcification in the wall, one with actual bone formation. The three teratomata were also in the anterior mediastinum. Two showed slight lobulation, the third was smooth; all were homogeneous in density. The neurogenic tumors included 10 neurofibromata, 2 ganglioneuromata and 2 neuroblastomata. They were in the posterior mediastinum in 9 cases and in the anterior in 5 cases. They were all smooth in outline and homogeneous in density. They showed bone erosion from pressure but no malignant invasion of bone. One unclassified malignant tumor showed slight lobulation with some atelectasis in the lung and a small amount of fluid in the pleural cavity.

Intrathoracic goiters are attached to the trachea. There was only one parathyroid tumor in the right upper mediastinum; it was a smooth mass with no special roentgen charac-

teristics but diagnosis was aided by the fact that the patient showed hyperparathyroidism, both clinically and roentgenologically. One benign thymoma in the anterior mediastinum cast a shadow overlying the pulmonary artery for which it was mistaken.—*Audrey G. Morgan.*

Alexander, Theodore O. Irradiation pneumonitis. *Bull. Johns Hopkins Hosp.*, Oct., 1944, *75*, 199–208.

This report concerns a fifty-two year old white male who was admitted to Johns Hopkins Hospital January 14, 1939 and who died September 28 of the same year. A diagnosis of Hodgkin's disease was made by biopsy of an axillary gland and roentgen examination of the chest showed widening of the mediastinum due to enlargement of lymph glands, and pulmonary infiltration more marked on the left side. Between January 21 and the date of death he received extensive roentgen therapy to various sites of involvement. His chief symptoms throughout were indicative of pulmonary involvement and though a good response was obtained to therapy over the mediastinum in the first five months of his illness, treatment was ineffectual thereafter and he died because of inability to sufficiently ventilate his lungs.

Between January 21 and March 1 he received 1,050 roentgens to anterior and posterior mediastinal fields, the lung fields being shielded. Between April 26 and May 4 he received an additional 420 r to these fields under similar conditions. From July 6 to September 28 he was treated over the mediastinum and lung fields, without shielding, 400 r to the lower right thorax, 2,261 r to the posterior mediastinum and 1,818 r to the anterior mediastinum —the total dosage of radiation without shielding of the lungs was, thus, 4,479 r given in approximately eleven weeks.

At autopsy there was no evidence of Hodgkin's disease in the lungs, though there were large, deep-staining Dorothy Reed cells in minute foci in the bronchial lymph nodes. The lungs showed characteristic lesions due to overirradiation such as have been described following animal experiments by Davis, McIntosh and Spitz, and Warren and Spencer. Grossly there were consolidated areas in both lungs and within the consolidation grayish-yellow areas of infiltration. Microscopic sections of both lungs "showed large groups of involved alveoli between which the tissue appeared unaffected by the irradiation, showing little but emphysema. Within these involved areas a few alveoli contained edema, a few leucocytes and red blood cells. Many alveoli contained a pink-staining fibrinous material which in places was condensed at the periphery to form a fibrinous, hyaline membrane. Various stages of organization of this exudate were evident, being so massive in areas as to obliterate the alveoli. The epithelium lining some of the alveoli was swollen and had in places desquamated into the adjacent air-containing spaces. A few, fat laden macrophages were dispersed throughout. Appropriate stains revealed no bacteria. . . . No evidence of Hodgkin's tissue in the lungs was found on examination of several sections." —*Angus K. Wilson.*

ABDOMEN

Abel, Martin S. A barium-gelatine mixture for x-ray examination of the digestive tract. *Radiology*, Aug., 1944, *43*, 175–180.

With the usual barium-water mixture the barium tends to settle out of the suspension quickly, and when a concentrated suspension is used the organ is rendered completely opaque. And the barium-water mixtures do not adhere to the wall of the gut so that in a moment no trace of them is left. The authors have devised a barium-gelatine mixture which overcomes all these difficulties. Two level tablespoonfuls of commercial gelatine are added to about 1½ glasses of hot water and stirred into solution; one teaspoonful each of 95 per cent ethyl alcohol and a saturated solution of bicarbonate of soda are added to this. This makes a viscous sticky medium which adheres to the wall of the intestine. It is only semi-opaque. The mucosal folds of the whole length of the esophagus are clearly shown when it is given. As the mixture is rather thin it is important to have the patient correctly angled, or the shadow of the esophagus will be superimposed on that of the heart or spine and will be hard to distinguish. For the stomach this mixture has no special advantage over acacia-barium mixtures but for the barium enema it has decided advantages. The walls of the colon are distended but not obscured by the semi-opaque medium. After evacuation the mixture is held tenaciously in the folds so that they are clearly seen.

This mixture has been used by oral administration in 100 cases at the Station Hospital at

the Mississippi Ordnance Plant at Jackson, Miss., and as a barium enema in 12 cases; on the basis of this experience it is recommended for use in the routine examination of all parts of the digestive tract.—*Audrey G. Morgan.*

Maxfield, J. R., Jr., and McIlwain, Albert J. Diagnostic value of pneumoperitoneum. *Radiology*, April, 1944, *42*, 346–355.

Stewart and Stein first popularized pneumoperitoneum as a method of diagnosis in this country in 1919 but it has never been given the attention it deserves. It is valuable not only in diagnosis but also in the treatment of certain diseases. Pneumoperitoneum occurs spontaneously in 75 to 80 per cent of cases of ruptured peptic ulcer. Induced pneumoperitoneum is to be used in conjunction with and not in competition with other methods of diagnosis. The authors believe the contraindications to its use have been overemphasized. They believe there are only two real contraindications—definite insufficiency of the heart and acute infection. The technique and the apparatus used are described in detail and roentgenograms given in cases in which it has proved of value. Carbon dioxide is to be preferred to oxygen or air in most cases as it is readily absorbed and causes discomfort for only a few minutes. The roentgenograms should be taken as soon as possible after the gas is injected.

Induced pneumoperitoneum may confirm or refute clinical findings. It enables the roentgenologist to study the size, shape and position of the abdominal and pelvic viscera, to determine the presence, location, extent or absence of abdominal adhesions, to establish the location of masses in the abdomen or retroperitoneal space, to obtain information regarding the presence and extent of peritoneal implants, to determine whether a lesion is above or below the diaphragm and to identify an intrauterine or abdominal pregnancy. In radiation therapy it makes it possible to remove the intestines from the field of irradiation.—*Audrey G. Morgan.*

Palmer, Walter L., Schindler, Rudolf, Templeton, Frederic E., and Humphreys, Eleanor M. Syphilis of the stomach; case report. *Ann. Int. Med.*, March, 1943, *18*, 393–406.

The patient was a male, thirty-six years of age, complaining of anorexia, bloating, distention, abdominal distress, nausea, vomiting and loss of weight. He had been perfectly well until eleven months previous to admission when he began to notice a continuing loss of appetite. Occasionally nausea appeared in the mid-afternoon and usually led to emesis unless relieved by food. In the six months prior to admission the patient had lost 25 pounds in weight. Additional history was essentially irrelevant except for the statement that at the age of seventeen, following coitus with an infected person, the patient had developed a pimple on the dorsal shaft of the penis over which a crust had formed with healing in four weeks. Physical examination was essentially negative. The blood Wassermann and Kahn reactions were both strongly positive on two occasions. The spinal fluid Wassermann test was negative. The cell count was 6, Pandy negative, the pressure normal, the coloidal gold curve normal.

A gastrointestinal examination was done and the impression of the radiologist was that there was a frank ulcerative lesion in the pyloric antrum and probably also the second portion of the duodenum, nature not determined. On gastroscopic examination the gastroscopist had the following impression: (1) carcinoma, Type III, of the antrum, limited by a wall at the lesser curvature but diffusely infiltrating the posterior wall; (2) extensive atrophic gastritis; (3) Type III carcinoma usually does not give a good prognosis but in this case the upper margin is so far distant from the cardia that the attempt of a resection must be made.

A partial gastrectomy was performed. Histopathologic examination of the lesion revealed that the outstanding characteristic was accumulation of inflammatory cells, both diffuse and perivascular, scattered small follicle-like groups of round cells, and gummatoid or tuberculoid granulomata, and a large but quite superficial ulcer.

The authors state that from the point of view of gross and microscopic pathology there are no absolutely pathognomonic lesions of gastric syphilis or indeed of syphilis anywhere in the body. In most cases the diagnosis must rest on presumptive evidence. The characteristics of the gastric lesion here presented are certainly similar to those reported cases in which there is little doubt of the syphilitic etiology. It is felt that this is almost certainly

an example of ulcerative gummatous syphilis, using the term gummatous in its broadest sense as applicable to all syphilitic lesions which terminate in scarification.—*J. J. McCort.*

Feldman, Maurice. Responsibility of the roentgenologist in the wartime duodenal ulcer problem. *Radiology*, April, 1944, *42*, 356–358.

The selective service regulations place the responsibility for the diagnosis of duodenal ulcer on the roentgenologist. If these ulcers are not diagnosed the patient may be found to have a duodenal ulcer after induction into the service, sometimes with serious complications such as perforation or hemorrhage. Since the roentgen demonstration of a marginal deformity or ulcer crater or niche defect is pathognomonic of duodenal ulcer, it is often thought that roentgen diagnosis of this condition is easy. But it must be remembered that these are not early signs and that to prevent overlooking these ulcers it is necessary to be familiar with the early mucosal changes such as veiling of the mucosal pattern, edema and superficial induration in the ulcerated area, elevating the mucosa, obliteration of the folds over the ulcer area, thickening of the folds, distortion of the longitudinal folds, cross-bar folding of the mucosa at right angles to the long axis of the duodenal bulb, a criss-crossing, lace-like or checker-board appearance of the mucosal pattern and convergence of the folds toward the ulcer. One of the earliest signs of duodenal ulcer is fragmentation of the barium-filled bulb due to localized edema and spasm. Though it is not so pathognomonic as marginal deformity or niche, it is sufficient for diagnosis and as it occurs in the earliest stage of ulcer it is very important to be able to recognize it. It is best demonstrated on roentgenoscopic examination, using manual compression. In addition to these mucosal changes, there are physiological changes that cause secondary roentgen signs such as irritability of the bulb of the duodenum, altered motility, altered tone and spasticity.—*Audrey G. Morgan.*

Reiley, W. E. Relation of coincident anomalies of the gastro-intestinal tract and renal ptosis to digestive disturbance. *Radiology*, July, 1944, *43*, 30–34.

A series of 179 patients (61 males and 118 females) with duodenal regurgitation were studied. This anomaly was found to be associated very frequently with abnormal mobility of the kidney and a short first metatarsal. Feet with short first metatarsals are weak and often associated with spastic piriformis muscles and movable kidney.

In 80 per cent of these cases with duodenal regurgitation there were digestive disturbances and in 72 per cent abnormal mobility of the kidney. The close relationship between the digestive and urinary tracts is not appreciated at its true value. Traction on the kidney pedicle causes a nervous response which results in nausea, vomiting, constipation, flatulence, nervousness and fatigue. Duodenal regurgitation is frequently a reflex from disease of the upper urinary tract and if seen it is an indication for careful examination of the urinary tract. Duodenal regurgitation, hypofunction of the gallbladder, spastic colon and movable kidney are frequently found associated and ptosis of the kidney is very common in gallbladder disease. Chronic gallbladder disease of itself does not cause nausea. If there is nausea it indicates a lesion of the upper urinary tract.

The duodenal regurgitation and other digestive disturbances associated with ptosis of the kidney may be relieved by an abdominal binder or nephropexy.—*Audrey G. Morgan.*

Hefke, H. W. The roentgen diagnosis of hypertrophic pyloric stenosis in infants. *Radiology*, Sept., 1944, *43*, 267–271.

The first symptom of hypertrophic pyloric stenosis in infants is vomiting which occurs about two to three weeks after birth. In the majority of cases it can be diagnosed clinically by palpation of the tumor but there are a certain number of cases in which roentgen examination is required for diagnosis. The most important roentgen sign is the narrowed prepyloric canal which can be demonstrated by fluoroscopy and on films. Films must be made in the right oblique position for on an anteroposterior view the pylorus and duodenal cap are often not seen.

The pyloric opening time is of importance. The normal pylorus in an infant will practically always open and discharge barium into the duodenum during the feeding. If the opening time is delayed more than five minutes pyloric stenosis is very probable. The emptying time

of the stomach is of much less importance. In many cases of proved disease with large tumors the opening time is delayed up to as long as an hour but the emptying time was normal, that is, in three to four hours no barium remained in the stomach.

Among more than 150 infants examined by the author on a suspicion of pyloric stenosis the tentative diagnosis was confirmed by roentgen examination and a Ramstedt operation performed. In 3 cases the clinical diagnosis was not confirmed by roentgen examination and no tumor was found on operation. In 38 cases the clinical diagnosis was not confirmed by roentgen examination and the later clinical course proved the roentgen diagnosis correct. After a Ramstedt operation the pyloric opening usually becomes normal in a short time.—*Audrey G. Morgan.*

Hunt, Claude J. Correlation of the x-ray diagnosis with the operative findings in small-intestinal obstruction. *Radiology*, Aug., 1944, *43*, 107–114.

Roentgen examination should be used much more than it is in the diagnosis of obstruction of the small intestine. In 1914 Case described gas shadows in the small intestine as an aid in the diagnosis of obstruction, and Kloiber in 1919 first stated that the diagnosis could be made from the gas shadows and a contrast medium was not necessary. But the typical transverse pattern described by Case is not necessary for the diagnosis of obstruction of the small bowel. Any collection of gas in the small intestine of an adult indicates obstruction and it develops within four or five hours of the beginning of obstruction. The distribution of the gas indicates the probable type of lesion. In mechanical obstruction by adhesive bands only the small intestine is distended while in paralytic ileus both the large and small intestine are distended. It may require a number of films to prove paralytic ileus. The painless abdomen is also a point in differential diagnosis and in fact both clinical and roentgen findings must be studied and carefully correlated. Simple mechanical obstruction may not require immediate operation but immediate operation is imperative in loop obstruction, volvulus or strangulation on account of the danger of gangrene of the intestine. Simple mechanical obstructions are probably the commonest type and they can be diagnosed early by roentgen examination. Typical cases of the various types are described and illustrated by roentgenograms.

In early cases the use of the Miller-Abbott tube is valuable in bringing about decompression. It may be dangerous in strangulated obstruction where the viability of the intestine is in danger. Intubation should be carried out by the roentgen department as it can be done successfully only under fluoroscopic control. The technique of intubation is described in detail.

The barium enema is valuable in the reduction of intussusception.—*Audrey G. Morgan.*

Viamonte, J. Manuel, and Farinas, Pedro L. Diagnóstico radiológico de la amebiasis cólica. (Roentgen diagnosis of amebiasis of the colon.) *Vida nueva*, Jan., 1943, *51*, 1–19.

Amebiasis is endemic in tropical countries and its diagnosis is very important. The clinical picture is characteristic in the late stages but it is important to diagnose it in the early stages when treatment is effective and the clinical picture at this stage may be confused with that of many other diseases. Roentgen diagnosis therefore becomes extremely valuable and is possible even at an early stage. The different stages of the disease are described and illustrated with drawings and roentgenograms of clinical cases.

Speder, working in French Morocco, classified the disease into six stages, the atonic, accordeon, rough cord, irregular, in which the contrast medium is distributed irregularly over the surface of the colon, rigid and filiform. These names are descriptive. To these the authors add those of diffuse and localized amebic tumor. These tumors may very readily be confused with the tumors of tuberculosis or syphilis. Examination may be made by a contrast meal or contrast enema, preferably both. Such examinations show the extent and the stage of the lesions.

Histopathological examination for amebae is not sufficient for it is positive in only about 20 per cent of the cases. Negative rectosigmoidoscopy does not disprove the disease as there are not always lesions of the rectum or sigmoid. It is hoped that this article will stimulate commoner use of roentgen examination in this disease.—*Audrey G. Morgan.*

Macht, Stanley H. Foreign body (bottle) in the rectum. *Radiology*, May, 1944, *42*, 500–501.

A case of foreign body in the rectum is described as a medical curiosity. The patient, a sailor thirty-one years of age, entered hospital complaining of pain in the lower abdomen, inability to defecate and bleeding from the bowel on attempted defecation. The day before he had drunk himself into an alcoholic coma. Roentgen examination showed a bottle, with its open end upward, in the sigmoid and iliac colon. Under spinal anesthesia it was extracted manually; in a week pain and tenderness had disappeared and the patient was discharged.

A number of other cases of curious foreign bodies in the rectum are reviewed from the literature. This is the eighth case in which a bottle in the rectum has been reported.—*Audrey G. Morgan.*

Faust, Daniel B., and Mudgett, Charles S. Visualization of the biliary tract with air and barium following a barium meal. *Ann. Int. Med.*, August, 1943, *19*, 356–367.

An excellent review of all the pertinent literature up to the present time is given. It was noted in the cases reviewed that the appearance of air in the gallbladder was due either to a gas bacillus infection of the gallbladder, or to a fistulous communication from the biliary tract to the stomach, the duodenum, or the colon, either spontaneous or surgical in origin. Numerous instances were recorded in which the biliary tract, in part or as a whole, has been outlined with barium following a barium meal or a barium enema but without air being noted in the biliary tract. In these cases spontaneous or surgical fistula were present in the great majority. In many instances there had apparently been a direct passage of a calculus from the gallbladder to the duodenum, either the duodenal bulb or the second portion of the duodenum, or to the colon—most commonly the hepatic flexure. Seventeen cases have been reported in which no fistula was demonstrated and in which the biliary tract was outlined with barium to a greater or less extent. In none of these cases without fistula was there any air noted in the gallbladder or common duct. It is believed in these cases that the barium gained entrance into the biliary tract through an incompetent sphincter of Oddi and perhaps this incompetency accounted for the symptoms in these cases.

In cases without fistula, as in those with fistula, the symptoms vary but in most instances were referred to the upper abdomen. A variety of conditions was noted in the cases with incompetency of the sphincter of Oddi, the most frequent being duodenal ulcer and tumors in the upper abdomen. No definite conclusions could be drawn from this small group of cases.

The authors were not able to explain in the case they reported the finding of air in the biliary tract by either a gas bacillus infection of the gallbladder or a fistula between the biliary and gastrointestinal tracts. There was undoubtedly relaxation of the sphincter of Oddi with general atony of the biliary tract. No case has been found in the literature in which the biliary tract has been visualized and air seen in the gallbladder without a fistula being present, as was in the case reported here. An exploratory laparotomy had been done on the patient. The stomach was found to be normal. The duodenum was opened and explored for a distance of 8 inches and no polyp, tumor, or ulcer was found. The gallbladder was adherent to the second portion of the duodenum and was easily freed. Traction from the cholecystoduodenal adhesions may have played a part in producing the incompetency of the sphincter of Oddi. Releasing the adhesions at operation followed by the use of a bland diet, low in fat, afforded this patient symptomatic relief.—*J. J. McCort.*

Baylin, George J., and Weeks, Kenneth D. Some roentgen aspects of pancreatic necrosis. *Radiology*, May, 1944, *42*, 466–470.

A case of pancreatic necrosis in a white cotton-mill worker forty-two years of age is described. He was admitted to the hospital with clinical signs that suggested obstruction of the large bowel and portal obstruction possibly due to cirrhosis of the liver. A plain roentgenogram of the abdomen showed a mottled appearance due to irregular rounded areas of increased density. They showed no calcification. A roentgenogram with a stomach tube in place showed the tube deflected to the right and upward. A study after giving a barium enema showed areas of spasm associated with loss of normal mucosal detail. These were in the mid-transverse colon, the splenic flexure and the ileocecal region. The mottling was attributed to fat necrosis and subsequent saponification resulting from pan-

creatitis. The displacement of the stomach to the right and upward was thought to be due either to swelling of the pancreas or to sealing-off of the foramen of Winslow with resu'tant accumulation of fluid in the lesser omental bursa. The intestinal spasm was thought to be due to the fat necrosis and the peri-intestinal inflammation caused by it. Operation confirmed the diagnosis of necrosis of the pancreas. The patient died and the autopsy findings are described in detail.

In this case the bases of the lungs were not roentgenographed, though basal exudates often occur in necrosis of the pancreas. The "inverted figure 3 sign" has been considered of great importance in changes in the head of the pancreas. The authors found it only once in the careful study of several cases of carcinoma of the pancreas. But on the basis of this sign plus spasm of the duodenum they made a diagnosis of pancreatitis which was confirmed by operation.—*Audrey G. Morgan.*

GENITOURINARY SYSTEM

Osgood, Ellis C. Value of the delayed examination in pyelography. *Radiology*, April, 1944, *42*, 380–381.

Sometimes, as in hydronephrotic kidney for example, diagnosis can be made from roentgenograms taken as long as twenty-four hours after retrograde pyelography when it could not be made from films taken immediately afterward. An illustrative case is described in a woman of eighty-one who came for examination on account of right lower quadrant pain irradiating to the back. Roentgen examination showed a large soft tissue mass in the right kidney area. A retrograde study on the right showed a circular dye shadow with poorly defined margins in the kidney region. A roentgenogram made twenty-four hours later showed that the dye had diffused throughout the soft tissue mass, showing that it was a large hydronephrotic sac.

To determine whether such late films should be made the routine films should be studied at once; the appearance of these films will also show the time that should elapse before the delayed examination is made.—*Audrey G. Morgan.*

Howes, William E. Kidney tumors; classification, review of symptoms. methods of diagnosis, therapy, and end-results. *Radiology*, April, 1944, *42*, 319–328.

Tumors of the kidney are difficult of diagnosis because they have generally grown to large size and often metastasized before they are discovered. Tumors of the cortex may not cause hematuria until they break into the pelvis and are not apt to cause pain until they invade the capsule; the patients seldom notice the mass themselves, at least until it is very large.

The Brooklyn Cancer Institute uses the following classification of kidney tumors: (1) tumors of the kidney cortex (*a*) papi'lary adenocarcinoma; (*b*) alveolar adenocarcinoma; (*c*) adenomyosarcoma (Wilms' tumor); (2) tumors originating in adrenal rests; hypernephroma; (3) tumors originating in the kidney pelvis: (*a*) papillary epithelioma; (*b*) alveolar carcinoma. Grawitz' theory that hypernephromas originate from adrenal rests in the kidney is now doubted. A large proportion of cases reported as hypernephroma are really renal adenocarcinoma. Primary kidney tumors may be radiosensitive but metastases, especially to bone, are radioresistant.

The author reports 59 cases of malignant tumor of the kidney seen at the Brooklyn Cancer Institute among a total of 6,400 admissions, or 0.65 per cent of admissions. Of these 45 were proved by autopsy or nephectomy while 9 were not confirmed pathologically. Pain was the outstanding and first symptom in 29 cases, hematuria in 21; in 4 the first sign was the abdominal tumor. Only 11 of the patients are still living and only 5 of these are free of metastases for over three years. The author has seen a recurrence of tumor twenty years after nephrectomy. Nephrectomy was performed in 38 of these cases and but 5 of these have survived over three years without known metastases. All of these surviving patients were given postoperative roentgen treatment and one was given large amounts of preoperative irradiation.

Unexplained back pain and loss of weight and strength should be considered indications for careful examination for kidney tumor and transitory hematuria should never be disregarded. Diagnosis is made by roentgen examination and clinical and laboratory findings. Bone metastases must not be confused with primary bone tumors. A further study should be made of the value of preoperative roentgen

irradiation. Histories and roentgenograms of noteworthy cases are given, and a tabulation of the end-results.—*Audrey G. Morgan.*

Bixler, Louis C., Stenstrom, K. Wilhelm, and Creevy, C. D. Malignant tumors of the kidney: review of 117 cases. *Radiology*, April, 1944, *42*, 329–345.

The history of tumors of the kidney is reviewed and 117 cases seen at the University of Minnesota Hospital from 1924 to 1940 discussed. These were followed up to the end of 1942. They included 94 cases of carcinoma of the renal cortex, 13 cases of Wilms' tumor, 9 of carcinoma of the renal pelvis and 1 of sarcoma. Tables showing the symptoms, treatment and results are given.

The average age of the patients was 53.4 years and 63 per cent were males and 37 per cent females. The chief symptoms were hematuria, pain, abdominal mass, loss of weight and weakness. Even the slightest hematuria should be considered an indication for thorough examination, including urography.

Metastases were demonstrated at the time of diagnosis in 14 of the 81 proved cases of carcinoma of the cortex. There is some question as to the advisability of nephrectomy if there are metastases at the time of diagnosis. The authors conclude that nephrectomy is not contraindicated by one small metastatic lesion in the lung or in bone. They believe that irradiation of metastases and recurrences is definitely worth while. Even if it does not prolong life it relieves pain and makes a fairly normal life possible for the patient. It seems to be generally agreed that irradiation alone does not cure carcinoma of the cortex. The value of postoperative irradiation is not established. The authors think it is worth while in some cases as it delays the growth of any cancer cells that may possibly remain.

Nephrectomy is the treatment of choice for malignant tumors of the kidney except Wilms' tumor. In Wilms' tumor irradiation seems to be of greater value than in any other form of malignant kidney tumor. The treatment in these cases consisted of surgery alone in 17 cases, surgery plus irradiation alone in 18 and irradiation alone in 13. Only cases proved histologically are considered in the results. The details of the roentgen technique used are discussed.

In adenocarcinoma of the cortex the five year survival rate for cases treated by surgery alone was 50 per cent, for cases by surgery plus irradiation 31 per cent, by surgery plus immediate postoperative irradiation 42 per cent and by irradiation alone 8 per cent. There were no five year survivals among the Wilms' tumor group, but 3 of the patients are still living and well with no signs of metastasis, 1 after four years and eight months. The survival rate in carcinoma of the pelvis is 16 per cent and for the whole series of kidney tumors 27 per cent.—*Audrey G. Morgan.*

MISCELLANEOUS

Wilson, C. W. Some condenser ionization chambers for the measurement of x-ray dose. *Brit. J. Radiol.*, March, 1944, *17*, 86–89.

Commercial dosemeters can be used for the ordinary measurement of the output of roentgen tubes, but for more specialized work suitable ionization chambers must be made in the laboratory workshop. The Victoreen dosemeter which makes use of the condenser chamber principle is the one usually preferred for the calibration of tubes; small condenser ionization chambers using the same principle may be used in conjunction with a suitable electrometer for most other types of investigation.

Two types of chamber are described and illustrated with diagrams. They are condenser ionization chambers with the Wulf bifilar electrometer. Their simplicity and usefulness is increased by the use of an air-wall material which is a bakelite-graphite mixture containing a small percentage of vanadium pentoxide; it can be moulded under heat and pressure. The first type is intended for routine calibration measurements of tube output. A small cylindrical ionization chamber is mounted at the end of a stem, in a manner similar to that of the Victoreen chamber. The second is intended for more experimental work, such as the determination of the volume distribution of radiation by means of direct measurements on patients. In this type the ionization chamber constitutes the whole apparatus, the maximum overall dimension being not more than 1 cm.

The behavior and response of the chambers when irradiated is described and graphs given showing the effect of wall thickness on the measurement of roentgen rays over a range of wavelengths.—*Audrey G. Morgan.*

Braestrup, Carl B. Depth dose measurements for 100-, 120-, and 135-kv. roentgen rays. *Radiology*, March, 1944, *42*, 258–272.

As larger doses are being used in the treatment of superficial cancer it becomes increasingly important to know the amount of radiation given to the underlying healthy tissue. This information has been limited by the lack of complete depth dose tables for low and intermediate voltages. This article is largely made up of tables showing phantom measurements of depth doses for half-value layers from 1.0 to 8.0 mm. aluminum (0.04 to 0.44 mm. copper). The equipment and measuring instruments are described and the comparative value of phantom materials discussed. Masonite presdwood should not be used for radiations produced at less than 200 kv. even if its density is unity. Water simulates human tissue much more nearly and its availability in a pure state permits of better duplication of results between different laboratories. The values obtained with presdwood are in general higher than those for water, especially at the greater depths.

The wide range of depth doses obtained with the four ray qualities used in this study indicates that low and intermediate voltage therapy could be carried out more effectively with a limited number of techniques. This would permit of better correlation between clinical results and physical factors. Half-value layers of 1.0, 2.0, 4.0 and 8.0 mm. aluminum as used here should be sufficient for most clinical purposes. And two target-skin distances, 15 cm. for small fields (5 cm. or less in diameter) and 30 cm. for large fields should be sufficient for the majority of superficial lesions.—*Audrey G. Morgan.*

Mayneord, W. V., and Clarkson, J. R. Energy absorption. II. Integral dose when whole body is irradiated. *Brit. J. Radiol.*, June, 1944, *17*, 177–182.

This paper discusses an experimental study of the absorption of energy during roentgen and radium treatment, particularly when the whole body is irradiated. The unit of integral dose suggested is the gram-roentgen—that is, the energy conversion when 1 roentgen is delivered to 1 gram of air. For clinical purposes 1 megagram roentgen, that is, 1 million gram roentgens is used.

A model of a patient was constructed that had elliptic cross-sections at all levels; it was made of paraffin wax and slabs of mixed rice flour and sodium bicarbonate. In measuring energy absorption in the model, condenser chambers were placed at the centers of mass of equal "cells" of a given section. The integral dose was obtained in three ways: (1) from the mean of the indications of the chambers (average dose method); (2) by drawing complete dose distributions in a given plane, followed by planimetry of the areas between dose contours, and (3) making use of the fact that under certain conditions the dose at the center of gravity of a cross-section is equal to the average dose in that section.

A very wide range of experimental irradiations was used, covering half-value layers from 0.037 mm. copper (40 kv.) up to 10 mm. copper (gamma rays of radium). Tables of the integral doses obtained in this way are given.

The average dose per roentgen on the skin for a patient of normal size varies from approximately 0.8 r for gamma rays to 0.175 r for low voltage irradiations. It is found that the integral dose per surface roentgen varies with quality in a complex way which may be predicted theoretically, the main practical result being that for half-value layers below approximately 1 mm. copper the integral dose falls very rapidly with decreasing half-value layer.

The relative integral doses in wax and in powder mixture were studied. The variation of the integral dose with changes in the direction of the roentgen-ray beam was also studied. The values for external radium sources were found by making use of reciprocity relationships between source and irradiated object.

The integral doses with smaller focal-skin distance roentgen techniques were measured in a few cases to provide data for those who use irradiation of the whole body with small doses. The importance of integral dose in problems of protection is pointed out, particularly with regard to the great variation of integral dose per surface roentgen with changes in half-value layer.

The measurements show the fallacy of considering 50 r in a whole body irradiation as a "small dose," for when applied in this way the integral dose may reach 3 megagram roentgens, an amount comparable with that absorbed during the whole of a severe localized treatment.

There is a marked increase of integral dosage rate on approaching powerful radium sources.

The study of integral dose will frequently show relationships that are not brought out by a study of dose alone.—*Audrey G. Morgan.*

Wolf, Bernard S. Nomographic aids in calculating radium dosage for plane and point sources. *Radiology*, April. 1944, *42*, 368–374.

Calculations of radium dosage were simplified by the contributions of Paterson and Parker published in the *British Journal of Radiology*. For radium sources filtered by 0.5 mm. platinum or its equivalent, distributed on square or circular areas, the number of milligram-hours required to deliver 1,000 gamma roentgens could be determined from a group of graphs. The same data can be put in the form of an alignment chart or nomogram. Such a nomogram is illustrated. It consists of three vertical scales. The area in square centimeters is given on the left-hand scale. The treatment distance in centimeters is given on the center scale. The right hand scale has divisions on both sides. The divisions on the right side of this scale are labeled at the top mg-hr. and the divisions on the left side are labeled %.

The method of using the nomogram is described and illustrated by examples and correction figures given for filtrations other than those equivalent to 0.5 mm. platinum and for tissue absorption if the source of radiation is surrounded by tissue. These data are based on the assumption that the source of radiation is a point, which of course it never is in actual practice. The calculated dose is therefore a little too high, but in the average case the error is not more than 5 per cent.—*Audrey G. Morgan.*

Jones, D. E. A. Dosage system for linear gamma-ray sources. *Brit. J. Radiol.*, Feb., 1944, *17*, 46–47.

In cases requiring radium treatment of an approximately cylindrical surface, such as the rectum, vagina or uterus, a linear radium source is generally used, contained in some form of tubular applicator. The dose is calculated at the middle point of the linear source. But this gives the maximum dose, as the dosage decreases towards the ends of the linear source. Where greater uniformity is necessary the axial source may be divided into three parts, the middle one of which is weaker than the two end ones. Calculations of the actual dosage rates are based on Sievert's formula for a linear source contained in an absorbing cylinder. The necessary formulas are gien and also two graphs showing the results which have been confirmed by experimental work at the Lambeth hospital for over two years using rectal applicators of the Tod type and vaginal colpostats. One of these graphs gives the percentage content of the central source and the other gives the milligram-hours required for a dose of 1,000 r for different shapes of applicator. If a considerable amount of a particular type of treatment is given in a hospital, such, for example, as carcinoma of the uterus, it is well to have sets of tubes made up of the size and content required for standard cases. In other cases supplementary radon sources may be used.—*Audrey G. Morgan.*